A REVIEW

OF THE

FOSSIL OSTREIDÆ OF NORTH AMERICA;

AND

A COMPARISON OF THE FOSSIL WITH THE LIVING FORMS.

BY

CHARLES A. WHITE, M. D.,

WITH APPENDICES BY PROF. ANGELO HEILPRIN AND MR. JOHN A. RYDER.

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LETTER OF TRANSMITTAL.

WASHINGTON, *June* 15, 1883.

SIR: I herewith transmit to you the manuscript of a Review of the Fossil Ostreidæ of North America, which, at your request, I have prepared for your Annual Report for 1883. The work is necessarily, to a large extent, a compilation of material that has already been published, but I have attempted to group that material in such a manner as to convey to the general reader an outline of the geological history of the oyster family, and the connection of the extinct with the living forms of oysters.

Two important parts of this work have been prepared by Mr. John A. Ryder and Prof. Angelo Heilprin, respectively. Mr. Ryder has prepared a concise life-history of the common living oyster of the Atlantic coast, which he has illustrated by original drawings of his own, and from material which he has prepared in connection with the United States Fish Commission.

Professor Heilprin has kindly furnished all that portion of the text which relates to the Tertiary and post-Pliocene oysters, which material is, in great part, the result of his special studies of the Tertiary mollusca of the United States.

All this work is, in accordance with your request, addressed to the general reader, rather than to the special student; but in doing this we have striven to avoid all scientific inaccuracy of statement. Like my contribution to your report for last year, this is a general review of the subject of which it treats, and not a revision or rectification of the forms which are enumerated and illustrated. Such a rectification is needed, but it must necessarily be deferred until another time.

The drawings, with the exception of the few that have previously been published, are from the pen of Dr. J. C. McConnell, who also drew the numerous illustrations for my contribution to your report for last year.

Besides the aid received from Messrs. Ryder and Heilprin, whose work appears under their respective names, I am also indebted to Mr. W. H. Dall, of the Coast Survey, and Lieut. Francis Winslow, United States Navy, for much information concerning the variation and distribution of the living oysters of our coasts.

A considerable number of the illustrations which accompany this memoir have been drawn from specimens belonging to the United States National Museum, by permission of the Director. He has also permitted the use of electrotypes of a portion of those illustrations which were already engraved and in possession of the Smithsonian Institution.

Respectfully submitted.

C. A. WHITE.

Hon. J. W. POWELL,
Director of the United States Geological Survey.

A REVIEW OF THE FOSSIL OSTREIDÆ OF NORTH AMERICA; AND A COMPARISON OF THE FOSSIL WITH THE LIVING FORMS.

By C. A. White.

INTRODUCTION.

Because of the great value of the common oyster as a favorite article of food, perhaps no subject connected with fossil conchology will be found to possess more interest to the general reader than that of the Ostreidæ, or oyster family. With this supposition in view I propose to present on the following pages a general review of that family as it is represented among the collections of fossil remains that have been made from North American strata. In addition to a general statement of the subject, with illustrations of the fossil forms, I shall give, for comparison, figures of the leading varieties of the oysters that are now found living upon our Atlantic coast. I had intended to illustrate the living oysters of the Pacific coast also, but I found it impracticable to obtain good specimens of them.

While much is known concerning the geological history of the oyster family within the area that now constitutes the North American continent, that history is and will doubtless always remain incomplete. This incompleteness is due mainly to the fact that among the fossil forms it is the shells alone that are available for study and to the further fact that these remains are usually few and very often too imperfect to exhibit all the characteristics which perfect shells possess. Besides this, the extreme variation in the form and other characteristics of the shell of the fossil, as well as the living Ostreidæ, renders their separation into species, and even into genera, a matter of much uncertainty. In the case of most other bivalve shells there is a certain precision of symmetry that is constant in every individual, from the earliest to the latest stage of its growth; but among the Ostreidæ, and especially in the typical genus *Ostrea*, asymmetry of the shell is the invariable rule. To what primary cause this a symmetry among the Ostreidæ is due, it is, with the present limitation of our knowledge, impossible to say; but it is certainly a characteristic of the whole family, including all its genera and its fossil as well as living forms.

The oyster family belongs to that division of the bivalve mollusca

known as the Monomyaria, or those whose shells are closed and held together by only one adductor muscle. (*a*)

Other bivalves, such as the common clam, for example, are known as the Dimyaria, and their two shells are closed and held together by two adductor muscles. As a rule, the shells of the Dimyaria are symmetrical, and the individuals of the various species are constant and regular in their respective shapes and in their ornamentation. It is also to an almost equal degree the rule that the shells of the Monomyaria are asymmetrical, and many of them also exhibit wide individual variation. There are, however, noted exceptions to both these rules; such, for example, as those which are presented by the unsymmetrical genera *Chama* and *Mülleria* (*b*) among the Dimyaria, and by the symmetrical *Pinna* and some species of *Pecten* among the Monomyaria.

Among the shells that are familiarly known, those which are most nearly related to the Ostreidæ belong to the genera *Anomia*, *Pecten*, *Spondylus*, *Avicula*, and *Pinna*. The most unsymmetrical of these belong to the genera *Anomia* and *Spondylus*, but the Ostreidæ exceed all other molluscan shells in asymmetry and extravagant variation.

Different authors have, from time to time, proposed separate generic names for certain more or less distinct groups of forms among the Ostreidæ, the greater part of which I regard as not even of subgeneric value. Some authors, on the other hand, reject all generic distinctions of the family Ostreidæ as it is presented in this memoir, and refer all the species to one and the same genus, the genus *Ostrea* of Linnæus. While it is no doubt true that among the fossil Ostreidæ, intermediate forms may be selected, which will closely unite all the groups of forms for which separate generic names have been proposed, it is regarded as expedient, if not actually necessary, to recognize among them at least two genera besides the genus *Ostrea* proper, and also one subgenus of the latter. These two genera and the subgenus referred to are recognizable only among the fossil forms, and only the genus *Ostrea* proper is recognized among the Ostreidæ now living in North American waters. Furthermore, although a considerable number of species of *Ostrea* have

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a In Mr. Ryder's article, on following pages, this muscle is described, and is also illustrated in the figures on Plate LXXIII. Its place of attachment to the shell is a conspicuous feature of the inner surface of each valve, as may be seen by referring to those figures on the accompanying plates which represent the inner surface of the shells.

b The genus *Mülleria* is a strangely modified group of the Unionidæ, or fresh-water clams. It is the shells of this genus, together with those of the related genus *Aetheria* (the former living in South American, and the latter in African rivers), that have been called fresh-water oysters. In their habits of growth and in their forms the shells of these two genera are suprisingly like those of true oysters, but they plainly do not belong to the Ostreidæ. *Mülleria* is said to possess no trace of the anterior adductor muscle in the adult and fixed state, in which respect it still further simulates the true oysters. But both of the adductor muscles are present in the young state and the shells are then also equivalve and symmetrical, like those of ordinary Uniones. Like them, the shell of *Mülleria* is also free in the young state.

been proposed among the living Ostreidæ of North America by different authors, it is now a serious question whether there is really more than one species of oyster now living in the Atlantic waters of North America. Those of the west coast of North America are not so well known, but at present three or four species are recognized there by the different authors who have studied them.

The shells of the Ostreidæ are inequivalve; that is, the two valves which, like those of all other true bivalve mollusks, are right and left respectively, are unequal in shape. The mollusk in a very early stage of its existence becomes attached to a foreign object, and the left valve also becomes attached to that object, leaving the right valve free. Sometimes the left valve becomes attached to the foreign object by the greater part of its exterior surface; but sometimes only by the point of the beak. When the surface of attachment is large, the shell to a great extent conforms to the surface upon which it is attached; and such shells are necessarily irregular in shape. When the surface of attachment is small, the shell is more regular in shape, but in no case are the valves wholly regular.

The three genera that are recognized in this memoir, and which have already been referred to, are *Exogyra*, *Gryphæa*, and *Ostrea*, and the subgenus of the latter is *Alectryonia*. (*a*) *Exogyra costata*, Say, may be taken as the type of this genus, and *E. forniculata*, White, as an intermediate form between *Exogyra* and *Gryphæa*. The former is represented on Plates LVI and LVII, and the latter on Plate LII. The shells of *Exogyra* are usually more regular in shape than those of any other genus of the Ostreidæ, but, as already stated, they are never wholly regular, and they are often much distorted. The left or under valve is always much the deeper, and the right or upper valve is usually flat. The beak of the lower valve is always turned strongly to the rear, (*b*) and it is usually more or less spiral. The inconspicuous beak of the upper valve also partakes of this deflected or spiral character. The shells of *Exogyra* are also, as a rule, more massive than those of any other of the Ostreidæ. This is especially true of the lower valve, which in *E. costata* and *E. ponderosa* sometimes reaches an inch and a half in thickness of solid shell substance. The genus *Exogyra* was a widely differentiated one in the Cretaceous period, within the region that now constitutes North America. It was not only represented by a considerable number of species, but those species embraced a wide variation of form, as may be seen by reference to the figures that represent them on the accompanying plates.

The genus *Gryphæa* is not so well represented in North American strata

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a The species which Conrad proposed to group under the generic name of *Gryphæostrea* I regard as not being even subgenerically distinct from *Ostrea* proper. See remarks under the head of *Ostrea vomer* on a following page.

b That is, to the left hand as one looks down upon the cavity of the valve, the hinge border being away from the person.

as *Exogyra*, and not more than two or three well-defined species are known there. Of these, *Gryphæa pitcheri*, Morton, which is illustrated on Plate XLIX, may be taken as the type. The beak of the lower valve of *Gryphæa* is usually strongly curved upward nearly in the plane of the median line, and as a rule not much deflected either to the right or left. The upper valve is like that of *Exogyra*, flat, or even slightly concave, and its beak inconspicuous and not deflected or coiled.

The American species of *Gryphæa* are very variable, and it is often difficult to say in what particulars many of the specimens differ from *Ostrea* proper.

The common living oyster of the Atlantic coast, *Ostrea virginica*, figures of different varieties of which are given on Plates LXXIII to LXXXII, may be taken as typical of the genus *Ostrea* proper, although several of the fossil species are equally typical of that genus, as may be seen by reference, for example, to Plates XXXVI and LX. All the living Ostreidæ of North America belong to the genus *Ostrea* proper; all other genera and subgenera of the family having become extinct.

The earliest known species of the family, which are of Carboniferous age, belong also to the typical genus. *Exogyra* and *Gryphæa* were apparently introduced in the Jurassic period, (*a*) flourished during the Cretaceous period, when the great oyster family culminated; and both those genera became extinct with the close of the Cretaceous period. But unlike those more differentiated forms just mentioned, *Ostrea* proper began its existence before the close of Paleozoic time and has also outlived both of its kindred but more differentiated genera. The subgenus *Alectryonia* was introduced with *Gryphæa* and *Exogyra*, but it survived them only one geological epoch, when it also became extinct.

The remains of the earliest known oysters, as has already been stated, were found in Carboniferous rocks. Professor de Koninck described *Ostrea nobilissima* from the Lower Carboniferous of Belgium, and de Verneuil described *O. matercula* from the Permian of Russia. Prof. A. Winchell described *O. patercula* from the Lower Carboniferous of Iowa, but no other trace of the family has been discovered in any other rocks of the Carboniferous age in North America. It is quite clear, however, that the oyster existed through the whole of that age, but it is also quite clear that it was never so abundant in that age as it became in the next, and as it remains to the present day.

Fossil oysters are not unknown in the Triassic rocks of Europe, but none have yet been found in North American strata of that age. In the Jurassic strata of this continent the family is only feebly represented, at least as compared with those of the Cretaceous period. Only one species of *Gryphæa* and three species of *Ostrea* have been published

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a Exogyra is known in European Jurassic strata, but in North America no species of that genus is known in any strata earlier than those of the Cretaceous period. Therefore in our studies of the North American rocks we regard *Exogyra* as distinctively characteristic of the Cretaceous period.

from the Jurassic rocks, one of the latter belonging to the subgenus *Alectryonia.*

It was in the Cretaceous period, as already mentioned, that the oyster family reached its culmination. At that time not only was there a great abundance of individuals, the remains of which are found in almost all the fossiliferous strata of that period, but there were living then a greater number of specific and generic forms than had ever existed before, and greater than have existed since. That is, the Ostreidæ not only became generally prevalent and abundant in the marine waters of this part of the earth at that time, but the whole family then reached a greater degree of variation as regards specific and generic form and feature than it has ever possessed at any other period.

Two facts in this connection seem to be not a little remarkable. First, the oyster family, which was an inconspicuous one among the mollusca up to the beginning of the Cretaceous period, then assumed, with apparent suddenness, a conspicuous position as regards general distribution, numbers of individuals, and wide differentiation of species and genera. Second, at the close of the Cretaceous period this differentiation was suddenly contracted to even narrower limits than it possessed at the beginning of the period, although the family still remained a conspicuous one as regards wide distribution, and numbers of individuals.

The abundance of oyster-life now existing in North American waters is apparent, when one considers the fact that with the present state of the art of preserving fresh foods, and the facilities for rapid transportation, the oyster has become a common article of food all over our country, inland, as well as upon our coasts. It seems certain, however, that the aggregate of oyster-life during the Cretaceous period was much greater than it is now. If there had at that time been human beings in existence to whom molluscan food would have been acceptable, the flesh of *Exogyra* and *Gryphæa* would, no doubt, have been as palatable as that of the true oyster. Of the latter, however, there has been no deficiency since at least the middle of Mesozoic time; and their flesh was, without doubt, in every way identical with that of living oysters.

Although the Ostreidæ, as a family, culminated in the Cretaceous period, different species of the genus *Ostrea* proper were abundant in Tertiary time; that is, in the period immediately following the Cretaceous. Certain of these species also reached a larger size than that of any which are known to have existed before or since, although some overgrown examples of *Ostrea virginica* that have been found upon the coast of Maine are reported to be nearly a foot and a half long.

The so-called fresh-water oysters of certain South American and African rivers have already been referred to, and it has been shown that they are not true oysters. In the oyster trade also the terms "salt-water oysters" and "fresh-water oysters" are used. The so-called fresh-water oysters of the dealers are true oysters, but they do not come from waters that are entirely, but only comparatively fresh. True oysters

cannot live in waters that are not more or less saline. It is a fact, well known to the trade, that great destruction of the oyster beds is liable to occur at and near the mouths of rivers during times of high and long-continued freshets in the rivers, by which an unusual quantity of fresh water is passed over them. Lieut. Francis Winslow, U. S. N., of the United States Fish Commission, has furnished me the following figures indicating the range of specific gravity from distilled water to that of the open sea, and also the minimum of that in which oysters will live.

Specific gravity of open-sea water	1.027
Specific gravity of the freshest waters in which oysters live	1.010
Specific gravity of distilled water	1.000

In giving the minimum specific gravity of waters in which oysters will live, Lieutenant Winslow does not mean to say that oysters immediately die when placed in fresher waters, but he cites authorities to show that the density of water cannot fall below 1.010 for any pro tracted period without destroying the oysters that may have previously lived in it.

It should be remarked that the specific gravity, as above given, is not necessarily an absolute indication of the proportionate amount of common salt in the water indicated, but it is approximately so. There are other substances held in solution in all sea and bay waters which, no doubt, have much influence upon the molluscan life they contain; but common salt is so largely in excess of these, that it is usual to consider that substance alone in such connection.

The common living oysters of our coasts are not unfrequently found in open sea waters, but their chosen habitat is in the waters of bays and estuaries, which are of less than marine saltness. From the facts here stated we see that there is a very considerable range of saltness of the water in which oysters will thrive.

In the case of the fossil Ostreidæ we cannot of course determine the amount of salt the water contained in which they lived, but there are certain circumstances attending the fossilization of those ancient oysters that tell us with evident approximation the degree of saltness which characterized those waters. Such a judgment of the character of those ancient and departed conditions is based upon our knowledge of the habits of living mollusks in general, and those of the oyster in particular.

For example, those oysters which are found living in open-sea waters are there associated, not with such mollusks as are its associates in bays and estuaries, but with such as live only in the open-sea. If, then, we find, as we often do, fossil oysters imbedded in strata, mingled there with the remains of other mollusks which are closely related to such living forms as are found only in the open sea, we necessarily infer that the oysters in question had an open-sea habitat. Again, if we find, as we often do, fossil oyster shells associated in the same strata with remains of mollusks, whose nearest living relatives are found only in brackish waters, we necessarily infer that those ancient oysters, like their kindred which now exist, were capable of living in brackish as

well as in marine waters. These conclusions are all the more reliable because the other living mollusks referred to are, as a rule, more restricted than oysters are, to certain degrees of saltness of the waters in which they live.

Reasoning from such facts as these, it is inferred that the fossil genera *Exogyra* and *Gryphæa* were denizens of the open-sea; that is, of the numerous species of these genera that have been discovered in the rocks of various parts of the world, none, so far as I am aware, have been found associated with such other fossil forms as indicate a brackish-water habitat, but all their associates indicate that they were denizens of marine waters.(*a*) The typical forms of *Ostrea*, on the contrary, while they occur abundantly in strata of different periods, mingled with marine associates, have been found also abundantly associated with other molluscan remains that we are compelled to regard as indicating a brackish-water habitat. Therefore we infer that the various species of the genus *Ostrea* proper have always been capable of living in both marine and brackish waters.

The geology of North America furnishes a most remarkable example of an abundance of brackish-water oysters during one of its geological periods. In that period, now known as the Laramie, and which immediately succeeded that in which the uppermost of the marine Cretaceous deposits were made, there existed the most remarkable inland sea that the earth has ever known. Its most southern limit, as at present known, is in Mexico, and its most northern in British America. Its fossil molluscan fauna shows that, like the existing Caspian, the waters of that sea were not of marine saltness, but brackish and fresh, or nearly so, in different parts and at different times respectively. Its present known molluscan fauna was illustrated in the report of the director for last year. Among its molluscan remains there is an abundance of oyster shells, which are found at isolated localities throughout that great formation. The presence of these shells, occurring as they do in many of the layers, shows that the waters in which they were deposited contained at least enough salt to make them brackish. The absence everywhere of true marine forms shows that the Laramie sea was nowhere and at no time of full marine saltness. In the deposits of all that great intra-continental sea no shells of either *Exogyra* or *Gryphæa*, nor any of the subgenus *Alectryonia* have been discovered.

All the remains of the oyster family which that great formation has yet furnished belong to the genus *Ostrea* proper. These facts are understood to indicate that the first named generic forms, as already intimated, were not capable of existing in any waters that were not of full marine saltness, while *Ostrea* proper throve abundantly in brackish

a It is possible that these genera also entered the estuaries that existed while they flourished, and that a knowledge of the fact has escaped us because estuary deposits of former geological ages are so rarely discovered. It is true, nevertheless, that the Ostreidæ of those genera flourished abundantly in association with mollusks and other animal forms that are characteristic of the open sea.

as well as marine waters. In closing these remarks it is proper to call attention to the modern aspect of the oysters of the great Laramie sea, as illustrated on Plates LVIII to LXI.

In the following treatment of the subject of this memoir I shall follow essentially the same plan that was adopted for the Review of the Non-Marine Fossil Mollusca in the Report of the Director for last year. A rectification of all the errors that have been made by different authors in their former publication of the species herein enumerated, is not attempted, but a part at least of the most obvious errors will be discussed or mentioned. Under the head of each geological period in which any of the Ostreidæ are known to have existed, and under the sub-headings respectively of the three recognized genera, all the species that have been proposed by different authors will be given in alphabetical order. The synonymy, at least in part, of each proposed species will be given in connection with its entry.

CARBONIFEROUS.

It has already been shown to be a well-recognized fact that the oyster began its existence early in the Carboniferous age, and that the species had at that early period the distinguishing characteristics of true *Ostrea*. It is somewhat remarkable, however, that while the fossil species of the later periods are, as a rule, represented by great numbers of discovered individuals, a sufficient number of examples of the three published species of Carboniferous oysters have not been discovered to give a satisfactory idea of all their respective specific characteristics. It is practically certain that throughout the Carboniferous age the oyster held a precarious existence, and that it was nowhere and at no time abundant until Mesozoic time.

Our knowledge of the existence of the oyster in North America during the Carboniferous age is based upon very slender evidence; only one species having yet been recognized, and only one example of that species having ever been discovered.

Genus OSTREA Linnæus.

Ostrea patercula Winchell.

(Plate XXXIV, Figs. 1, 2.)

The specimen upon which the description of this species was based was obtained from the Kinderhook Group of the Lower Carboniferous strata at Burlington, Iowa. The description, without illustration, was published by Professor Winchell in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1865, page 124. The figures of the shell, which are given on Plate XXXIV, are copies of Professor Winchell's unpublished drawings.

JURASSIC.

It has already been stated that no examples of the Ostreidæ have been found in any of the Triassic strata of North America. This deficiency makes a great hiatus in the geological history of the family, between the Lower Carboniferous and Jurassic periods. It is probable, or even practically certain, that members of the oyster family existed in North America during the Triassic period, but no direct evidence of it has yet been obtained. One reason at least for the absence of such evidence is the great paucity of organic remains of all kinds in the Triassic strata of this continent.

The slight extent to which the Ostreidæ are represented in the Jurassic strata of North America, as compared with the Cretaceous strata which overlie them, is perhaps largely due to a similar cause. That is, the molluscan fauna of the Jurassic period is only feebly represented in North American strata, compared with like faunæ of other periods, and of the same period in other parts of the world. Still, considering the geological history of the oyster family as a whole, as it is now known, the lack of an abundance of its remains in the American Jurassic strata is probably due largely to the fact that the family had not yet reached its full development.

Four species only of the Ostreidæ have been found in North American Jurassic strata, but the genus *Gryphœa* appears among them, besides typical *Ostrea* and the subgenus *Alectryonia.*

Genus OSTREA Linnæus.

Ostrea engelmanni Meek.

(Plate XXXIV, Figs. 3, 4.)

This species was originally published by Mr. Meek in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1860, page 311. It was afterwards republished with wood-cut illustrations in Paleontology of the Upper Missouri, pages 72–74. This is a well-marked species of typical *Ostrea;* but it is rare, only a few examples of it, mostly imperfect, having ever been discovered. These were found in what is now the eastern portion of Wyoming Territory, but which was a portion of Nebraska Territory at the time the species was first discovered.

Ostrea strigilecula White.

(Plate XXXV, Figs. 9, 10, 11.)

At almost all localities in Wyoming, Colorado, Utah, and Idaho where the Jurassic rocks are found to be fossiliferous, the shells of a small oyster are to be found. They are usually imperfect, both by fracture and also by corrosion or wave-attrition. The best examples I have seen are

described and figured in Reports of United States Explorations and Surveys West of the 100th Meridian, Vol. IV, p. 163, Plate XIII, Figs. 3, *a*, *b*, *c*, *d*.

This shell is sometimes found associated with *Gryphæa calceola*, var. *nebrascensis;* and some of the more capacious examples so far approach that species in form as to suggest the possibility that *O. strigilecula* may really be a variety of the *Gryphæa*, with which it is sometimes found associated.

Ostrea (*Alectryonia*) *procumbens* White.

(Plate XXXV, Figs. 6, 7, 8.)

Only a few examples of this species are known, and these are all imperfect. The best of them are here figured for the first time. They were discovered in Northwestern Colorado, and described in Powell's Report on the Geology of the Uinta Mountains, page 93.

Genus GRYPHÆA Lamarck.

Gryphæa calceola Quenstedt, var. *nebrascensis* Meek & Hayden.

(Plate XXXV, Figs. 1, 2, 3, 4, 5.)

This American representative of the European *Gryphæa calceola* is not abundant in our Jurassic strata, but it has been found at a considerable number of localities in the great Rocky Mountain region. As already remarked in connection with *Ostrea strigilecula*, the typical forms of this species, although they have all the characteristics of *Gryphæa*, are found associated with intermediate and transitional forms that can, with propriety, hardly be separated from the *Ostrea*. The species in question is fully described by Meek & Hayden in Paleontology of the Upper Missouri, pages 74–76. Five wood-cut figures of it are given there, which are reproduced on Plate XXXV.

The geographical distribution of this form is considerable, examples of it having been found at distant localities in Wyoming and Idaho. The first discovered American specimens, as the name implies, were found in what was then a part of the great Territory of Nebraska; but it is not likely to be found within the limits of the present state of Nebraska. Although specific limitation among the Ostreidæ is often so difficult to determine, I think it would not be unreasonable to regard this form as fully distinct from the European one of Quenstedt.

CRETACEOUS.

The difficulty of discriminating and defining species, even among the living Ostreidæ, has already been referred to, and this difficulty is far greater in the case of the fossil forms. This fact will be obvious to any one who scans the following annotated list, and the accompanying illus-

trations of Cretaceous Ostreidæ. While a considerable number of the names which are given in the following list are shown to be synonyms, or to represent spurious species, it is probable that some of those which are given as representing true and distinct species, ought really to pass into the list of synonyms. Much work needs to be done by a competent student, upon the North American fossil Ostreidæ, especially upon those of the Cretaceous period. The utility of treating the fossil Ostreidæ upon the basis of definite specific diagnoses is becoming more and more questionable; and I am convinced that a more general treatment of the subject will, in the future, be the more rational.

Genus OSTREA Linnæus.

Ostrea americana Deshayes.

See *Exogyra costata* Say, on a following page, with which it is synonymous.

Ostrea anomiœformis Roemer.

Professor Roemer described this form as a species of *Ostrea*, in Kreidebildungen von Texas, page 75, Plate IX, Figs. 7, *a*, *b*, *c*, *d*, *e*. The interior of Professor Rœmer's shell is not known; but in external character it is so closely like certain known forms of *Anomia* that I believe it to belong to that genus. It is, therefore, not considered in this memoir.

Ostrea anomioides Meek.

(Plate XXXIX, Figs. 4, 5.)

Mr. Meek described this form without illustrations in the annual report of the United States Geological Survey of the Territories for 1872. It was afterward illustrated by myself in that series of reports for 1878, Plate XI, Figs. 4 and 4 *a*. Those figures, as well as those which illustrate the species on Plate XXXIX, are drawn from Mr. Meek's type specimens.

Ostrea appressa Gabb.

(Plate XXXIX, Fig. 9.)

The form published by Mr. Gabb under this name is probably identical with his *O. idriaënsis*. This view is suggested, both by the close similarity of the two forms and the fact that both are reported to come from one and the same formation, the Tejon Group of California. The difference between them is certainly no greater than it is between certain of the varieties of the living *Ostrea virginica*, as may be seen by referring to the figures on Plates LXVII to LXXXII. Some geologists and paleontologists, notably Professor Heilprin, contend, and with much apparent reason, that the Tejon Group ought to be referred to the Tertiary period and not to the Cretaceous. For the present, however, I leave this species with the Cretaceous fauna, where Mr. Gabb placed it

in the Paleontology of California, Vol. II, page 203. The illustration which is given on Plate XXXIX is copied from his figure on Plate 34, Fig. 4, of the volum equoted.

Ostrea bella Conrad.

(Plate XXXIX, Fig. 6.)

This small species was published by Conrad in the report of the United States and Mexican Boundary Survey, Vol. I, p. 156, Plate X, Figs. 4, *a*, *b*. It is probably too closely like the form which was named *Ostrea elegantula* by Dr. Newberry to be regarded as a distinct species. See remarks under the head of that name on a following page.

Ostrea bellarugosa Shumard.

In his Monographie du Genre Ostrea, page 69, Professor Coquand gives the name of "*O. bellarugosa* Shumard." I am not acquainted with the publication of any oyster by that name. It is probably a misprint or a supposititiou for *O. belliplicata* Shumard.

Ostrea belliplicata Shumard.

(Plate LXXVIII, Figs. 1, 2, 3.)

Dr. Shumard described this handsome species without figures in the Transactions of the Saint Louis Academy of Science, Vol. I, page 608. I afterward published a description of it with figures in the Annual Report of the United States Geological Survey of the Territories for 1877, p. 276, Plate IV, Figs. 3, *a*, *b*; and Plate 8, Figs. 2, *a*, *b*. This species appears to be quite constant in its form and general characters. All the known examples are from Texas.

Ostrea blackii White.

(Plate XLV, Fig. 1, and Plate XLVI, Fig. 2.)

This form is of a similar type with *O. belliplicata*, and it is possibly only a variety of that species. Both forms are from the Cretaceous strata of Texas, but I am not aware that they have ever been found associated together. *O. blackii* is a larger and less ventricose shell and has coarser plications than *O. belliplicata*. The former was originally described and figured in the Proceedings of the United States National Museum, Vol. II, page 293, Plate 4, Figs. 1, 2. It was also similarly published in the Annual Report of the United States Geological Survey of the Territories for 1878, page 11, Plate XIV, Figs. 1, *a*, *b*; and Plate XVII, Fig. 4.

Ostrea barrandei Coquand.

(Plate XLIV, Figs. 1, 2; Plate XLV, Fig. 2; Plate XLVI, Fig. 1.)

This remarkably fine species was published in France by Professor Coquand in his Monographie du Genre Ostrea, page 47, Plate XII, Figs.

1–4. He states that his type specimens were obtained from New Jersey, but so far as I am aware no other examples of the species have ever been discovered. The illustrations of this species in this memoir are copies of Professor Coquand's figures in the work cited.

Ostrea breweri Gabb.

The figure given under this name in Paleontology of California, Vol. I, Plate 26, Fig. 191, is that of an imperfect lower valve, and the brief specific description on page 204 of that volume is not more satisfactory. The figure apparently represents an oyster closely related to *O. coalvillensis*, and also to *O. wyomingensis* Meek.

Ostrea bryani Gabb.

This form is briefly described without illustration in the Proceedings of the Philadelphia Academy of Natural Sciences for 1876, page 321. It is reported as coming from the Cretaceous of New Jersey.

Ostrea carinata (Lamarck) Roemer.

(Plate XLIII, Figs. 1, 2, 3, 4.)

This species was originally described from the European Cretaceous, but Professor Roemer discovered it among his Texas collections and published it in Kreidebildungen von Texas, page 75, Plate IX, Fig. 5. Professor Coquand regards the Texas form as *O. pectinata* Lamarck; but although it seems to vary somewhat from *O. carinata*, I am disposed to agree with Professor Roemer in his determination. Fig. 1 on Plate X is a copy of Professor Roemer's figure, and Figs. 2, 3, 4 are drawn from a specimen sent from Texas by Mr. George Stolly, of Austin.

Ostrea coalvillensis Meek.

(Plate XXXVI, Figs. 1, 2, 3, 4.)

In the reports of the United States Geological Survey of the 40th Parallel, Vol. IV, page 140, Plate XV, Figs. 10, *a*, *b*, *c*, Mr. Meek suggested this name for an oyster which was obtained from the marine Cretaceous strata at Coalville, Utah. In aspect and details it is closely like *O. wyomingensis*, which, however, comes from the Laramie Group. (See remarks under *Ostrea wyomingensis* on a following page.)

Ostrea confragosa Conrad.

Conrad described this species from the Cretaceous strata of Mississippi in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. III (n. s.), page 329. On Plate 34, Fig. 4, of that volume he gave one small figure, which does not possess sufficient character to give any satisfactory idea of the species.

Ostrea congesta Conrad.

(Plate XXXIX, Figs. 11, 12, 13.)

Perhaps no fossil species of oyster is more common and more widely distributed in the Cretaceous strata of western North America than *O. congesta.* It is a small shell; and almost always the lower valve is broadly attached to some foreign body, notably upon the large shells of *Inoceramus.*

Ostrea convexa Say.

(See *Gryphæa vesicularis,* on a following page, with which it is regarded as identical.)

Ostrea cortex Conrad.

(Plate XXXVII, Figs. 3, 4.)

The form to which Conrad gave this name was found by the United States and Mexican Boundary Commission at "Dry Creek, Mexico." It is briefly described on page 157 and figured on Plate IX of Vol. I of the report of that commission. Copies of part of those figures are given on Plate XXXVII; but they are unsatisfactory, both upon zoological and geological grounds. They will serve, however, to add to the fullness of illustration of the fossil Ostreidæ.

Ostrea crenulata Tuomey.

Not the *O. crenulata* of Lamarck. (See *Ostrea tuomeyi* Coquand, a Cretaceous species; not *O. tuomeyi* Conrad, a Tertiary species.)

Ostrea crenulimargo Roemer.

(Plate XLIII, Figs. 8, 9.)

Professor Roemer published this form in Kreidebildungen von Texas, page 76, Plate IX, Figs. 6, *a*, *b*. The *O. quadriplicata,* afterward published by Shumard, is almost certainly identical with this species. Large collections of specimens show intermediate forms connecting those which were described by Professor Roemer and Dr. Shumard, respectively. (See *O. quadriplicata* on a following page.)

Ostrea crenulimarginata Gabb.

(Plate XL, Fig. 2.)

This species is reported from the Cretaceous rocks of Tennessee, and published in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. IV (n. s.), Plate 68, Figs. 40, 41. Little is known concerning its identity.

Ostrea cretacea Morton, Owen.

(See *O. franklini* on a following page.)

Dr. Morton, in his Synopsis of the Organic Remains of the Cretaceous Group, page 52, Plate XIX, Fig. 3, published a species under the

name of *Ostrea cretacea*, supposing it to have come from Cretaceous strata in Alabama. It has since been ascertained that the strata from which his specimens were obtained are of Tertiary and not Cretaceous age. This species has therefore been included in the list of the Tertiary Ostreidæ by Professor Heilprin on a subsequent page. In the Second Report of the Geological Survey of Arkansas, Plates VII and VIII, Dr. Owen figured an oyster from Cretaceous rocks of that State which he referred to the *Ostrea cretacea* of Morton. Without knowing that they came from different formations, Professor Coquand regarded them as representing two distinct species. Therefore, in his Monographie du Genre Ostrea, page 53, Plate XXIII, Figs. 8–10, he mentioned and figured Dr. Owen's form, and named it *Ostrea franklini.*

Ostrea denticulifera Conrad.

This is another form the publication of which is very unsatisfactory. It was described in the Journal of the Academy of Natural Sciences of Philadelphia, Volume III (n. s.), page 321. On Plate 34 of that volume, Figs. 1 and 8 are given as illustrations of the species, but they are not of such a character as to give much aid in specific identification. Mr. Conrad's examples came from the Cretaceous strata of Mississippi.

Ostrea diluviana Linnæus.

(Plate XL, Fig. 1; Plate XLI, Figs. 1, 2.)

Some interesting specimens of this form were sent to the Smithsonian Institution some years ago from the Cretaceous rocks of Bell County, Texas. They seem to be specifically identical with the long-known *O. diluviana* of Linnæus. At least they are so nearly like that European species that I do not feel warranted in placing the Texan form under a separate name. This shell has the toothed margin, and to some extent, also, the characteristic marginal outline of *Alectryonia*, and it ought perhaps to be ranged under that subgenus.

Ostrea elegantula Newberry.

(Plate XXXVI, Figs. 5, 6, 7.)

Prof. J. S. Newberry, in his Geological Report which accompanies that of Captain Macomb's Exploring Expedition, page 33, proposed the name *Ostrea elegantula* for a small Cretaceous species which he found abundantly in the valley of Canadian River, but he gave neither description or figures of it. Professor Newberry has kindly furnished for this article authentic specimens from his original collection, figures of which are given on Plate XXXVI. This form is probably identical with *Ostrea bella* Conrad, but as I am not quite certain of this, I give both names a place in this list. Professor Newberry's reference to his form was written before the publication of Conrad's description, but his report was not published until long afterward, in 1876.

Ostrea exogyrella Gabb.

Mr. Gabb published this form without figures in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1876, page 322. He reported it from the Cretaceous strata of Georgia, but so far as I am aware it has not since been recognized.

Ostrea falcata Morton.

(See *Ostrea larva* Lamarck, on a following page, with which Morton's form is regarded as identical.)

Ostrea franklini Coquand.

(Plate XXXIX, Figs. 1, 2, 3.)

Dr. D. D. Owen figured but did not describe this form on Plates VII and VIII of the Second Report of the Geological Survey of Arkansas, and referred it to the *Ostrea cretacea* of Morton. (See remarks under the head of *O. cretacea* on a preceding page.)

"*Ostrea gabbanna* Meek & Hayden."

This name appears in Meek's Check List of North American Cretaceous Fossils, but it is believed that no description or illustration of it has ever been published.

Ostrea inornata Meek.

A description and figure of this small form are given by Mr. Meek in Vol. IX of the United States Geological Survey of the Territories, page 14, Plate X, Fig. 4. The latter is an unsatisfactory representation of a species, and the description fails to convey a clear idea of it.

Ostrea idriaensis Gabb.

(Plate XXXIV, Figs. 7, 8.)

Mr. Gabb described both this form and *O. appressa* from the Tejon Group of California. Under the head of the latter name on a previous page I have suggested that both forms probably belong to one and the same species. *O. idriaensis* is figured by Mr. Gabb on Plates 33 and 34 of Vol. II, Paleontology of California, and it is described on page 203 of the same volume.

Ostrea (*Alectryonia*) *larva* Lamarck.

(Plate XLII, Figs. 2, 3, 4, 5, 6, 7, 8, 9.)

This variable species has probably a wider geographical distribution than any other Cretaceous *Ostrea;* and it has been known under more than a dozen specific names. It is known in various parts of Europe, in Southern India, and in different parts of the United States, especially in New Jersey and Alabama.

Morton in his synopsis proposed for three American varieties of this shell the three specific names *falcata*, *nasuta*, and *mesenterica.*

Ostrea lateralis Nilsson.

Certain authors have regarded the *Ostrea vomer* of Morton as identical with the European one described under the name *O. lateralis* by Nilsson. I regard them as distinct. (See remarks under the head of *Ostrea vomer* on a following page.)

Ostrea littlei Gabb.

Under this name Mr. Gabb described a form without illustration, in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1876, page 321. It is reported from the Cretaceous of Georgia.

Ostrea lugubris Conrad.

(Plate LI, Fig. 3.)

All the known examples of this species are so small as to suggest that they may be the young of a larger species; but it seems to be very constant in size and in other general characteristics. It is common in certain of the Cretaceous rocks of Colorado and New Mexico. It was originally published in the report of the United States and New Mexican Boundary Survey, Vol. I, page 156, Plate X, Figs. 5 *a*, *b*.

Ostrea lyoni Shumard.

Dr. Shumard published this form from the Cretaceous strata of Texas, without illustration, in the Proceedings of the Boston Society of Natural History, Vol. VIII, page 200. Similar mention has been made of other species which have been published without illustration. It is difficult at best to correctly illustrate a species of the Ostreidæ even by the use of numerous and well preserved examples; and in the present state of publication of the fossil forms it is almost impossible to identify any species, even a well-marked one, by a written description only.

Ostrea malleiformis Gabb.

(Plate L, Fig. 8.)

Mr. Gabb obtained this species from the Cretaceous rocks of California, and published it with one figure in Vol. II of the Paleontology of that State, page 204, Plate 31, Fig. 272.

It is characterized by wing-like expansions of the cardinal portion, and seems to be a well-marked species.

Ostrea mesenterica Morton.

(See remarks under the head of *Ostrea larva* on a preceding page.)

Ostrea mortoni Gabb.

Mr. Gabb described this form as coming from Cretaceous strata, but Professor Heilprin regards it as a Tertiary species. (See his remarks under the same head on a following page.)

Ostrea multilirata Conrad.

(Plate XXXVIII, Figs. 1, 2.)

No very perfect examples of this species have been obtained, but it is apparently a well-marked one. Conrad's types were collected near the boundary between Mexico and Texas, and published in the report of the United States and Mexican Boundary Survey, Vol. I, page 157, Plate XII, Fig. 1, *a*, *b*, *c*, *d*.

Ostrea nasuta Morton.

This form is regarded as only a variety of *Ostrea larva* Lamarck. (See remarks under the latter head on a preceding page.)

Ostrea owenana Shumard.

Dr. Shumard published this form without illustration in the Proceedings of the Boston Society of Natural History, Vol. VIII, page 200. It was obtained by him from the Cretaceous strata of Texas. Not being illustrated it seems impracticable to identify it from the description alone.

Ostrea panda Morton.

Dr. Morton described this form as coming from Cretaceous strata; but Professor Heilprin regards it as of Tertiary age. (See his remarks under the same head on a following page.)

Ostrea pandæformis Gabb.

This species was described by Mr. Gabb in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1861, page 328. It is reported to come from the Cretaceous of Mississippi, but not having been illustrated it seems impracticable to identify it.

Ostrea patina Meek & Hayden.

(Plate XLVII, Figs. 4, 5, 6.)

This is a very common yet variable species in the Cretaceous strata of the Upper Missouri River region. Mr. Meek referred it with some doubt to the genus *Gryphæa*. It is described and figured in Vol. IX of the United States Geological Survey of the Territories, page 16, Plates X and XI.

Ostrea peculiaris Conrad.

Conrad described this species in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. III (n. s.), p. 329. On Plate 34 of that volume he gave a single figure of a small shell, but it is too indefinite to be of use in the identification of the species. It is reported to come from the Cretaceous rocks of Mississippi.

Ostrea pellucida Meek & Hayden.

(Plate L, Figs. 6, 7.)

This is not the *Ostrea pellucida* of Defrance 1821, but it is a small species from the Cretaceous of the Upper Missouri River region, which was published in Vol. IX of the United States Geological Survey of the Territories, page 15, Plate XXVIII, Figs. 4, *a*, *b*. It is probably the form that Dr. Morton supposed to be identical with his *O. falcata* (= *O. larva*), but it is quite distinct, as was shown by Mr. Meek. It is also evidently the same form that was described by Meek & Hayden under the name of *O. translucida* in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1857, page 147. Both that form and the one they called *O. pellucida* are reported from the same formation and same locality, and they are probably identical. A clear specific characterization has not been given of either of the forms; but in any case the name *O. pellucida* cannot hold, because it was used long ago by Defrance for a different species. The latter name is probably an inadvertent supposititíon on the part of the authors for the previously used name *O. translucida*.

Ostrea planovata Shumard.

Dr. Shumard described this form in the Proceedings of the Boston Society of Natural History, Vol. VIII, page 201. In the same paper both *O. lyoni* and *O. owenana* were published among other Cretaceous fossils from Texas. As no illustrations of either of these species have been published, and as the type specimens are not accessible, it seems impracticable to identify them among any collections subsequently made.

Ostrea plumosa Morton.

(Plate XXXVII, Figs. 5, 6.)

Dr. Morton obtained this species from the Cretaceous strata of New Jersey, and published it in his Synopsis of the Cretaceous Formation of the United States, page 51, Pate III, Fig. 9. It seems to be a very variable form, and the figures here given, although they correctly represent the specimens used, are not very satisfactory.

Ostrea prudentia White.

(Plate XL, Figs. 5, 6.)

The only specimens of *O. prudentia* that have yet been discovered were obtained from the Cretaceous strata of Southern Utah. It was originally published in the reports of the United States Explorations and Surveys West of the 100th Meridian, Vol. IV, page 171, Plate XIV, Figs. 2, *a*, *b*, *c*, *d*.

Ostrea quadriplicata Shumard.

(Plate XLIII, Figs. 5, 6, 7.)

Under the entry of *Ostrea crenulimargo* on a previous page it has already been stated that the form bearing that name is believed to be

identical with this. Professor Roemer and Dr. Shumard obtained their respective specimens from the Cretaceous strata of Texas. Dr. Shumard described *O. quadriplicata* in the Transactions of the Saint Louis Academy of Science, Vol. I, page 608, without illustrations. I afterward obtained copies of his unpublished drawings, and published them together with others in the Annual Report of the United States Geological Survey of the Territories for 1877, Plate VIII, Figs. 3, *a*, *b*. Copies of those figures are given on Plate XLIII.

Ostrea robusta Conrad.

(Plate XL, Figs. 3, 4.)

Conrad published this form in the Report of the United States and Mexican Boundary Survey, Vol. I, page 156, Plate IX, Figs. 3, *a*, *b*. His type specimens came from the Cretaceous strata near Laredo, Texas.

Ostrea (*Alectryonia*) *sannionis* White.

(Plate XLV, Figs. 3, 4, 5, 6, 7.)

Up to the present time this species has been found only at Coalville, Utah, where a considerable number of specimens were obtained. It is a well marked and apparently constant form. It was first published in Powell's Geology of the Uinta Mountains, and afterward illustrated in the Annual Report of the United States Geological Survey of the Territories for 1877, Plate II, Figs. 2, *a*, *b*, *c*, *d*, *e*.

Ostrea soleniscus Meek.

(Plate XLII, Fig. 1.)

This remarkable species is found in the Cretaceous rocks of Southern Wyoming and the adjacent parts of Utah and Colorado. The typical examples are very long and slender, sometimes reaching a length of eighteen inches with a width of only two and a half or three inches. Associated with these long, slender forms, I have found some that are scarcely more elongate than ordinary oysters. In view of the great elongation of one variety of the living *Ostrea virginica*, such, for example, as is illustrated on Plate LXXXI, I am much disposed to regard these short fossil forms as belonging to the same species as the slender ones with which they are associated. Mr. Meek described *O. soleniscus* in the Annual Report of the United States Geological Survey of the Territories for 1872, page 487. I gave two figures of it in the same series of reports for 1878, on Plate XI of that volume.

Ostrea subalata Meek.

(Plate XXXIX, Fig. 10.)

The type specimen described by Meek under the name of *Ostrea* (*Gryphæostrea ?*) *subalata* in Volume IX of the United States Geological Survey of the Territories, page 15, and figured on Plate 28, Fig. 5, was obtained from the Cretaceous strata of the Upper Missouri River region. It has not since been satisfactorily identified.

Ostrea subovata Shumard.

Dr. Shumard briefly described this form in the report of Marcy's Exploration of the Red River of Louisiana, page 193. He gave one figure of it on Plate 5 of that volume, but it is too indistinct to be of any service in the identification of the species. I suspect, however, that Shumard's form is identical with the one I have mentioned on a previous page under the name of *O. diluviana* Lin.

Ostrea subspatulata Forbes.

(Plate XXXVII, Figs. 1, 2.)

The type specimens of this species were obtained by Sir Charles Lyell in New Jersey, and published by Forbes, with two wood-cuts, in the Quarterly Journal of the Geological Society of London, Vol. I, page 61. It has since been somewhat unsatisfactorily identified in the Cretaceous rocks of the Gulf States, but it has not been anywhere recognized as an abundant form.

Ostrea tecticostata Gabb.

(Plate L, Figs. 4, 5.)

Mr. Gabb reported this form as coming from the Cretaceous strata of Tennessee and New Jersey. It is published in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. IV (n. s.), page 403. Two small, unsatisfactory figures of it are given on Plate 68 of that volume.

Ostrea torosa Morton.

Dr. Morton published a form under this name in his Synopsis of the Cretaceous Formation of the United States, page 52, Plate X, Fig. 1. It is evidently, as Gabb has pointed out, only a distorted example of *Exogyra costata* Say. (See remarks under that head on a following page.)

Ostrea translucida Meek & Hayden.

See remarks on a previous page under the head of *Ostrea pellucida*. If, as is supposed, this form is identical with that which the same authors described under the name of *O. pellucida*, the latter name must give place to *O. translucida*, because it was preoccupied by Defrance in 1821.

Ostrea tuomeyi Coquand.

Professor Tuomey obtained this species from the Cretaceous strata of Alabama. It has never been figured, but it was described by him under the name of *Ostrea crenulata* in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1854, page 171. This name having been preoccupied by Lamarck in 1801, Professor Coquand, in his Monographie du Genre Ostrea, page 68, gave Professor Tuomey's species the name of *O. tuomeyi*.

Conrad seems to have intended to give the name *Ostrea tuomeyi* to a

Tertiary species, but he never properly published it. (See Professor Heilprin's remarks under the same head on a following page.)

Ostrea uniformis Meek.

(Plate XLVIII, Figs. 6, 7.)

In the report of Macomb's Exploration, page 124, Plate I, Figs. 2, *a*, *b*, *c*, Mr. Meek published a form from New Mexico, which appears to be a well-marked species; but so far only the type specimen is known.

Ostrea vellicata Conrad.

This species is not satisfactorily known. Conrad described and figured it in the Report of the United States and Mexican Boundary Survey, Vol. I, page 156, Plate XI, Figs. 2, *a*, *b*. It does not perhaps differ specifically from *O. cortex*, by the same author, which is figured on the same plate.

Ostrea vomer Morton.

(Plate XLVIII, Figs. 8, 9, 10.)

Dr. Morton published this form in his Synopsis of the Cretaceous Formation of the United States, page 54, Plate IX, Fig. 5, under the above name. Mr. Gabb and others have regarded it as identical with the *Ostrea lateralis* of Nilsson; but it appears to me to as well deserve a separate name as many other American forms which resemble European species. Conrad made it the type of his proposed genus *Gryphæostrea.* I do not, however, regard the characters upon which that proposed genus was based as even subgenerically distinct from those of true *Ostrea.*

Genus GRYPHÆA Lamarck.

Gryphæa mucronata Gabb.

This name was proposed by Mr. Gabb in Paleontology of California, Vol. II, page 274, for the variety of *G. pitcheri* to which Conrad had previously given the name *G. navia.*

Gryphæa mutabilis Morton.

(See *Gryphæa vesicularis* Lamarck.)

Grgphæa navia Conrad.

As above stated, Gabb gave the name *G. mucronata* to this form. Professor Roemer figured it on Plate IX of Kreidebildungen von Texas as *G. pitcheri*, and he was doubtless right, as *G. pitcheri* is a very variable species, and *G. navia* is regarded as only a variety.

Gryphæa pitcheri Morton.

(Plate XLIX, Figs. 1, 2, 3, 4, 5, 6.)

This is perhaps one of the most widely distributed and most variable species among the Ostreidæ of North America. It was originally dis-

covered in the Cretaceous strata of New Jersey, and published by Dr. Morton in his Synopsis of the Cretaceous Formation of the United States. It has since been recognized in widely separated localities in the United States and Mexico. Some of the varieties lose the prominence of the beak of the lower valve, and approach an ordinary oyster in appearance. A variety of this species, somewhat common in Texas, is narrower than the typical form and has a more produced beak to the lower valve. Conrad gave this form the name of *G. navia*, as already mentioned. Figures of it are given on Plate XLIX.

Gryphœa thirsœ Gabb.

Mr. Gabb described this as a Cretaceous species, but according to Professor Heilprin it is found in true Tertiary strata. He regards it as not generically distinct from the *Ostrea*, and it will be found on a following page among the Eocene species under the name of *Ostrea thirsœ*.

Gryphœa vesicularis Lamarck.

(Plate XLVIII, Figs. 1, 2, 3, 4, 5.)

The species which is arranged under this name is a somewhat variable one. Dr. Morton published certain specimens of it under the name of *Ostrea mutabilis*, and Say published others as *Ostrea convexa*. These American forms are now generally regarded as specifically identical with the long-known European species *Gryyhœa vesicularis* of Lamarck. It is found in the Cretaceous rocks of the Atlantic and Gulf States.

Gryphœa vomer Morton.

Dr. Morton described this species as a *Gryphœa*, but I regard it as not generically distinct from true *Ostrea*. (See remarks under *Ostrea vomer* on a preceding page.)

Genus EXOGYRA Say.

Exogyra arietina Roemer.

(Plate LVI, Figs. 3, 4, 5.)

This species is quite a common one in the Cretaceous rocks of Texas and the adjacent parts of Mexico. It is generally known under the above name, which was published in Kreidebildungen von Texas, page 68, Plate VIII, Figs. 10, *a*, *b*, *c*, *d*, *e*, but it possibly ought to be called *Exogyra laxa* Say. In 1826 Mr. Say described a shell under the name of *Delphinula laxa* which, from its resemblance to certain specimens of *E. arietina*, and my lack of knowledge of any other species to which it may belong, I believe to have been a specimen of the larger valve of this *Exogyra*. If I am correct in this supposition, Say's specimen was that of a fossil instead of a recent shell, and an *Exogyra* instead of a *Delphinula*. Say's very brief and unsatisfactory description of *D. laxa* may be found

on page 156 of Binney's edition of Say's writings and Mrs. Say's excellent figures of it on Plate 7 of that volume.

Conrad published this species under the name of *Exogyra caprina* in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. II (n. s.), page 273, Plate XXIV, Figs. 3, 4. Roemer's name must remain, however, because it was previously published, unless the name *Exogyra laxa* Say shall be used.

Exogyra aquila Goldfuss.

(Plate LIII, Figs. 1, 2.)

The specimens which are here recognized as belonging to the *Exogyra aquila* of Goldfuss were sent to the Smithsonian Institution some years ago by Mr. D. A. Walker, from Bell County, Texas. Upon comparing them with the figures given by Goldfuss in his Petrefacta Germaniæ, page 36, Plate 87, Fig. 3, no features appear to me upon which a specific difference can be based. I am not aware that this species has before been recognized in American strata, but various authors have reported it from different parts of Europe and from both Northern and Southern Africa.

Exogyra columbella Meek.

(Plate LV, Figs. 5, 6.)

This small species of *Exogyra* has hitherto been found only in Southern Utah and the adjacent parts of New Mexico, where it is sometimes found associated with *E. læviuscula* Rœmer, which species it resembles in size. It was published by myself in the reports of United States Explorations and Surveys west of the 100th Meridian, Vol. IV, page 174, Plate XVII, Figs. 3, *a*, *b*, *c*, *d*. I there regarded it as a small variety of *E. costata*, and gave it the variety name of *fluminis*. In the same year Mr. Meek published this form under the name of *E. columbella*, in the Report of Macomb's Exploration, page 124, Plate I, Figs. 3, *a*, *b*, *c*, *d*.

Exogyra costata Say.

(Plate LVI, Figs. 1, 2; Plate LVII, Figs. 1, 2.)

This is one of the most common and characteristic as it is one of the largest species of *Exogyra* that are found in the Cretaceous rocks of the United States. It is especially characteristic of certain strata in the Atlantic and Gulf States, and also in Mexico. It is usually quite constant in its form and in the costate character of its surface, but in the latter respect it is sometimes variable. Indeed, some authors regard *Exogyra ponderosa* Roemer as only a variety of *E. costata*, differing only in the obsolescence of its costæ. This feature is so constantly present in the one form and absent in the other that I prefer to regard them as representing distinct species.

Exogyra fimbriata Conrad.

This proposed species is really unworthy of notice, because its original description was based upon only a single upper valve, which is probably that of a small example of *Exogyra ponderosa*. Conrad published it in the Report of the United States and Mexican Boundary Survey, Vol. I, page 154, Plate VII, Figs. 2, *a*, *b*. Adding still further to unnecessary synonymy, the name is, by typographical error, given as *E. foliacea* on Plate 7, Vol. I of the United States and Mexican Boundary Survey. Furthermore, Coquand, in his Monographie du Genre Ostrea, page 60, proposed to change Conrad's supposititious name to *O. sabfimbriata*.

Exogyra forniculata White.

(Plate LII, Figs. 1, 2.)

The gradation of the genus *Gryphæa*, which has before been referred to, is exemplified by this species, which might with equal propriety be referred to either genus. The principal distinguishing characteristic of *Exogyra* I have taken to be the lateral deflection and greater or less curvature of the beak of the lower valve. The full development of this feature is shown in such forms as *E. costata* and *E. læviuscula*, and the minimum, in the species heading this paragraph. So far as I am aware *Exogyra forniculata* has been found only in Texas and the adjacent parts of Mexico. It has often been confounded with the variety of *Gryphæa pitcheri* to which Conrad gave the name *G. navia*. It was originally published as a distinct species in the Proceedings of the National Museum Vol. II, page 293, Plate IV, Figs. 3, 4; and subsequently in the Annual Report of the United States Geological Survey of the Territories, page 13, Plate 14, Figs. 2, *a*, *b*.

Exogyra fragosa Conrad.

This form is perhaps only a variety of *E. ponderosa*, but it was published as a distinct species by Conrad in the Report of the United States and Mexican Boundary Survey, Vol. I, Plate VIII, Figs. 2, *a*, *b*. It was obtained from Cretaceous strata of Texas.

Exogyra interrupta Conrad.

Mr. Conrad published a form under this name from the Cretoceous strata of Mississippi in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. III (n. s.), page 330, Plate 34, Fig. 15. The figure is very unsatisfactory, and apparently represents a young and small example of the lower valve of a species like *E. winchelli*.

Exogyra læviuscula Rœmer.

(Plate LII, Figs. 3, 4, 5.)

Professor Rœmer published this species from the Cretaceous strata of Texas in his Kreidebildung von Texas, page 70, Plate IX, Figs. 3, *a*, b,

c. It has also been found in New Mexico, and in the State of Nuevo Leon, Mexico. It is a well marked and not very variable species.

Exogyra Matheroniana d'Orbigny.

Conrad, in the Report of the United States and Mexican Boundary Survey, referred certain specimens to this species that are specifically identical with the form that Professor Rœmer described under the name of *Exogyra texana*. (See remarks under that head in a following paragraph.) It is a somewhat common form in the Cretaceous of Texas and the adjacent parts of Mexico.

Exogyra plicata Lamarck.

It is doubtful whether this species exists in North American rocks. Certain authors have placed specimens under this name which I believe to belong to the *E. texana* of Rœmer. (See remarks under that head in a following paragraph.)

Exogyra ponderosa Rœmer.

(Plate L, Figs. 1, 2, 3.)

This massive form is common in certain Ceretaceous strata of the States which border the Gulf of Mexico; extending westward into the Republic of Mexico. It was first published by Rœmer in Kreidebildung von Texas, page 71, Plate IX, Figs. 2, *a*, *b*. As before remarked, it has by some authors been regarded as not specifically different from *E. costata* Say. The two forms are certainly closely similar, but their surface characters are apparently constant in their difference, even when they are found associated in the same stratum. The lower valve of this species is very massive in old examples, sometimes reaching nearly two inches in thickness of solid shell substance.

Exogyra parasitica Gabb.

(Plate LV, Figs. 3, 4.)

Mr. Gabb published this form in Paleontology of California, Vol. I, page 205, Plates 26 and 31. It is interesting because of the very slight representation that *Exogyra* has in the Cretaceous strata of the Pacific coast.

Exogyra texana Rœmer.

(Plate LI, Figs. 1, 2, 3, 4, 5.)

Professor Rœmer published this species in Kreidebildung von Texas, page 69, Plate X, Figs. 1, *a*, *b*, *c*, *d*, *e*. It is not unfrequently found in certain Cretaceous strata in Texas and the adjacent parts of Mexico. It has been by various authors referred to *E. plicata* Lamarck, and *E. Matheroniana* d'Orbigny.

Exogyra walkeri White.

(Plate LIV, Figs. 1, 2.)

This is a large, compressed form, which comes from the Cretaceous strata of Texas. It was published in the Annual Report of the United States Geological Survey of the Territories for 1877, page 278, Plate I, Figs. 1, *a*, *b*.

Exogyra winchelli White.

(Plate LV, Figs. 6, 7; Plate LVI, Figs. 1, 2.)

The form which is most nearly related to this species is the *E. haliotoidea* of Sowerby, but it is more elongate than that shell, and the front side is more abruptly elevated. It is probable that this American form might be with propriety recognized as a variety of the European *E. haliotoidea*, but I prefer at present to regard it as distinct. I have recognized the last-named species among some Cretaceous fossils from Brazil, and they seem to be sufficiently distinct from *E. winchelli*. It is only in the Cretaceous strata of the Gulf States that *E. winchelli* is yet known. It was published in the Proceedings of the United States National Museum, Vol. II, page 294, Plates II and III; and also in the Annual Report of the United States Geological Survey of the Territories for 1878, page 12, Plate XIII, Figs. 1, *a*, *b*, *c*, *d*.

LARAMIE GROUP.

The great brackish water formation of Western North America, which is known as the Laramie Group, has already been referred to. In this great formation no true marine fossil remains have been found, but oyster shells are not unfrequently found in its strata, and in some places they are abundant. Among these no less than five species have been proposed by different authors, but later collections show such gradations of form that I have not been able to recognize more than two species among them, and it is probable that there is really only one species in the whole formation.

These oyster remains of the Laramie Group not only belong to the typical genus *Ostrea*, but the most abundant of the two recognized species is very closely like the living *Ostrea virginica*. This species is quite constant in its typical form, even at points more than a thousand miles distant from each other, and the extent of its geographical distribution seems to have been quite equal to that of the living *O. virginica*.

Ostrea glabra Meek & Hayden.

(Plates LVIII, LIX, LX, LXI.)

This widely distributed species was first published under the above name in the Proceedings of the Academy of Natural Sciences of Phil-

adelphia, for 1857, page 136. The type specimens were obtained from the Upper Missouri River region; and the smoothness which suggested their specific name was not natural, but due to attrition or corrosion. Figures of one of these type specimens are given on plate LVIII. In the Annual Report of the United States Geological Survey of the Territories, for 1872, page 508, Mr. Meek described a form from Southern Wyoming under the name of *Ostrea wyomingensis*, figures of which are given on Plates LX and LXI. In the same series of reports, the volume for 1873, page 477, he described another form from the same locality under the name of *O. arcuatilis.* Fig. 5, on Plate LIX, is drawn from his type specimen.

In Powell's Report on the Geology of the Unita Mountains, page 112, I described another form from Southern Wyoming under the name of *O. insecuris.* Figures of the type specimen are given on Plate LIX. Now, all these forms, as before mentioned, I regard as belonging to one and the same species.

Ostrea subtrigonalis Evans & Shumard.

(Plate LXI, Figs. 4, 5, 6, 7.)

This small form occurs in the Laramie strata of the Upper Missouri River region. It is not improbable that this also is a variety of *O. glabra*, but the somewhat numerous specimens that have hitherto been discovered are very uniform in size and shape, the size being considerably smaller than the average of *O. glabra.* It was originally published without figures; but it was identified by Meek and illustrated by him in Vol. IX of the United States Geological Survey of the Territories, Plate 40, Figs. 1, *a*, *b*, *c*, *d*.

APPENDIX I.

NORTH AMERICAN TERTIARY OSTREIDÆ.

By Prof. Angelo Heilprin.

Genus Ostrea Linnæus.

EOCENE.

Ostrea alabamensis Lea.

(Plate LXIV, Figs. 2, 3, 4.)

Originally published from Alabama in Lea's Contributions to Geology, page 91, Plate III, Fig. 71.

Syn.—*O. lingua-canis* Lea. Ib., page 92.
O. pincerna Lea. Ib., page 92.
**O. semilunata* Lea. Ib., page 90.

Ostrea carolinensis Conrad.

From South Carolina. Published in Conrad's Fossil Shells of the Tertiary Formation, first edition, page 27, Plate 14, Fig. 1.

Ostrea compressirostra Say.

(Plate LXV, Figs. 1, 2.)

Published from Maryland, in the Journal of the Philadelphia Academy of Natural Sciences, IV, page 132.

Syn.—*O. bellovacina* Conrad; Proceedings of the National Institute, page 172.

It appears to me very doubtful whether the character of the beaks pointed out by Say (Journal of the Academy of Natural Sciences, IV, page 133) to distinguish this species from the *O. bellovacina* Lamarck, is a constant one or not, and I have therefore some hesitation in recognizing it as a distinct species. The beaks of *O. compressirostra* certainly do appear more compressed than they are shown to be in the majority of figures representing the European oyster; but at least some of the specimens in the collection of the Philadelphia Academy of Natural Sciences of *O. bellovacina* (var. *edulina*) from the London Clay of Bognor, have the beak undistinguishable from those of the American species.

The want of specimens with which to make the proper comparisons, and the difficulties that attach to the definition of the specific charac-

* This last form is very distinct from the *O. sellæformis* of Conrad, which is noticed on a following page.

ters of the Ostreidæ prevent me from expressing a definite opinion as to the relationship of the two species. The figures of *O. bellovacina* as given by Searles Wood in his Monograph of the Eocene Mollusca (Paleontological Society's Reports for 1861, Plate VIII, Figs. 3, *a*, *b*, *c*), accord almost perfectly with the American oyster. The oyster found by Lyell in the "Grove" about 17 miles north of Charleston, S. C., and which appeared to him "undistinguishable from *O. bellovacina*" (Journal of the Geological Society of London, I, page 433) is probably the *O. carolinensis* Conrad, a form very closely allied to *O. compressirostra.*

Ostrea cretacea Morton.

This species, described by Morton in the Synopsis of the Organic Remains of the Cretaceous Group, page 52, Plate XIX, Fig. 3, is found in South Carolina and Alabama (?). It is given as Eocene on the authority of Gabb (Proceedings of the Philadelphia Academy of Sciences for 1861, page 328; "Mollusca of the Cretaceous Formation," page 152) and is not included in Conrad's Check List.

Ostrea divaricata Lea.

(Plate LXIV, Fig. 1.)

This was published by Lea among his collections from Alabama in his Contribution to Geology, page 91, Plate III, Fig. 70.

SYN.—*O. flabellula*? Lamarck.

In the Proceedings of the National Institute (1841–'6, page 193), as well as subsequently (American Journal of Conchology, I, page 15), Conrad unhesitatingly refers this species to his *O. sellæformis*—a view which appears to me to be decidedly erroneous. Although the two species closely resemble each other in the young stage, they may, nevertheless, on close inspection, be readily distinguished from each other. The distinguishing characters between *O. divaricata* and *O. falciformis* Conrad (American Journal of Conchology, I, page 140) are not so easily made out, and I must confess my inability thus far to discover what they are. The *O. divaricata* certainly agrees very closely with the figures and description of Lamarck's *O. flabellula*, to which species it is in fact unhesitatingly referred by Nyst (Coqu. et Polyp. Foss., page 323) and Giebel (Repertorium to Goldfuss' Petrefacta Germaniæ, 1866, p. 41). The last is a very variable and one of the most widely dispersed of fossil oysters, its range extending from Alabama (Deshayes; and d'Orbigny, Prodrome de Paléontologie, II, page 394) to Cutch, in India, and Cairo, in Egypt (Deshayes, Anim. sans Vertèbr. Bassin de Paris, II, page 121.)

Ostrea eversa Mellville sp.

(Plate LXIV, Figs. 5, 6, 7, 8.)

A fossil of the French Eocene (Deshayes, Anim. sans Vertèbr. Bassin de Paris, II, page 99, Plate 84, Figs. 5–8), identified in the Eocene of Maryland and Mississippi.

SYN.—*Gryphostrea eversa* Conrad. Smithsonian Check List.

Ostrea falciformis Conrad.

American Journal of Conchology, I, page, 140. From Mississippi.

SYN.—*O. divaricata?* Lea. Supra.

Ostrea mortonii Gabb.

From Alabama and South Carolina. Proceedings of the Academy of Natural Sciences of Philadelphia for 1861, page 329.

SYN.—*O. panda* (pars) Morton. Synopsis Organic Remains, page 51.

Ostrea sellæformis Conrad.

(Plate LXII, Figs. 1, 2; Plate LXIII, Fig. 1.)

From the Eocene of Alabama, South Carolina, and Virginia. Published by Conrad in his Fossil Shells of the Tertiary Formation, first edition, page 27.

SYN.—*O. radians* Conrad; same work and page.

Ostrea thirsæ Gabb.

(Plate LXIII, Figs. 4, 5, 6.)

This form was published by Gabb as a Cretaceous species in the Proceedings of the Philadelphia Academy of Sciences for 1861, page 329; but it is now known that the strata from which it comes are of Eocene age. Gabb referred it to the genus *Gryphæa*, but, although it approaches *G. vesicularis* in form, I am disposed to place it under true *Ostrea*.

Ostrea trigonalis Conrad.

Proceedings of the Philadelphia Academy of Natural Sciences, VII, page 259. From Mississippi.

? Ostrea tuomeyi Conrad.

This name is given by Conrad, No. 695 of the Smithsonian Check List, as coming from Mississippi. I have seen no specimens of this species, nor have I been able to discover where it is described.

OLIGOCENE.

Ostrea georgiana Conrad.

Conrad published this species in the Journal of the Philadelphia Academy of Natural Sciences, VII, p. 156. It is reported as coming from Georgia, South Carolina, Mississippi, and Lower California (?). There is a large oyster in the collection of the Academy from Lower California, marked *O. georgiana*; it certainly greatly resembles that species, but its characters are to some extent obliterated, which prevents absolute identification. I should not be surprised if, on comparison with European specimens, the *O. georgiana* will be found to be only a variety of *O. crassissima* Lamarck (Miocene of a very large portion of Europe).

The resemblance of the figures of that species is very great; and if the American oyster does not assume quite the ponderous proportions of its European cousin, the circumstance may be due to local causes, such as crowding. Conrad states that this species reaches a length of 22 inches.

Ostrea vicksburgensis Conrad:

(Plate LXIII, Figs. 2, 3)

This species is from the well-known locality of Vicksburg, Miss. It was published in the Journal of the Philadelphia Academy of Natural Sciences, Vol. I (n. s.), page 126.

MIOCENE.

Ostrea atwoodi Gabb.

(Plate LXVIII, Figs. 4, 5.)

This species is said to be either Miocene or Pliocene. It was published in the Paleontology of California, II, pages 33, 34; Plate X, Figs. 58, 58*a*; and Plate XI, Fig. 58*b*.

Ostrea borealis Lamarck.

This fossil form is identified with a recent species.* It is published in Lamarck's Animaux sans Vertèbres, second edition VII, page 220.

There are in the Academy's collections four specimens of an oyster marked "St. Charles, Maryland, Cope" which answer perfectly to Lamarck's species. It is probably Miocene.

Ostrea contracta Conrad.

(Plate LXIX, Figs. 1, 2.)

This species is reported by Conrad as coming from Oyster Point, Mexico, and as probably Miocene. It is published in the Report of the United States and Mexican Boundary Survey, I, page 160, having been previously published in the Proceedings of the Philadelphia Academy of Natural Sciences, VII, page 269.

Ostrea disparilis Conrad.

(Plate LXVI, Figs. 1, 2.)

From Virginia and South Carolina. Conrad's publication of the species is in his Fossils of the Medial Tertiary Formation, page 51, Plate 26.

SYN.—*O. raveneliana* Tuomey & Holmes, in Pliocene Fossils, page 21.

The differences which were pointed out by Tuomey & Holmes as separating *O. raveneliana* from *O. disparilis* cannot be said to exist.

* See Plate LXXX for recent specimens.

Ostrea panzana Conrad.

Conrad published this form as coming from California in the Pacific Railroad Reports, VII, p. 193. He regarded it as possibly the mature shell of *O. subjecta*. I have seen no specimens of this species; nor is it determinable from Conrad's figures. Gabb was unable to recognize it among the collections of the California Survey.

Ostrea percrassa Conrad.

(Plate LXVII, Fig. 3.)

This Miocene form has hitherto been recognized only in New Jersey. Conrad published it in his Fossils of the Medial Tertiary Formation, page 50, Plate 25, Fig. 1.

Ostrea sculpturata Conrad.

(Plate LXX, Fig. 2.)

From Virginia. Published in Fossils of the Medial Tertiary Formation, page 50, Plate XXV, Fig. 3.

SYN.—*O. virginiana* var. Conrad (non Gmelin): Fossils of the Tertiary Formations, first edition, p. 28.

Ostrea subfalcata Conrad.

(Plate LXVIII, Figs. 1, 2, 3.)

From Virginia. Published by Conrad in his Fossils of the Medial Tertiary Formation, page 50, Plate XXV, Fig. 2.

Ostrea subjecta Conrad.

Reported as coming from California, and published in the Pacific Railroad Reports, VII, page 193. I have seen no specimens of this species, nor is it determinable from Conrad's figure. Gabb was unable to recognize the form among any of the collections of the California Survey.

Ostera tayloriana Gabb.

(Plate LXVII, Fig. 1, 2.)

From California. Published in Paleontology of California, II, p. 34, Plate 12, Figs. 60, 60*a*.

Ostrea titan Conrad.

Conrad published this large oyster in the Proceedings of the Philadelphia Academy of Natural Sciences, VI, page 199; the Journal of the same (n. s.), IV, page 300, and the Pacific Railroad Reports, VI, page 72.

This is to my knowledge the most ponderous oyster found in the United States. In certain of its forms it so closely resembles the *O. gingensis* of Schlotheim as to be but barely separable from the common European species. Like it, it also affects the long, the curved, and the scooped forms, the space between the valves in the last case being very

capacious. All traces of radiate plications, if it ever possessed any such ornamentation, have disappeared in the specimens before me. The long forms may be readily distinguished from the *O. crassissima* Lamarck by the comparative shortness of the umbonal region.

Ostrea veleriana Conrad.

(Plate LXX, Fig. 1.)

This species was collected in Arizona by the United States and Mexican Boundary Commission, and published in Vol. I, Part II, page 160. It is stated to be probably Miocene.

Ostrea virginica Gmelin (=*O. virginiana* Lamarck).

SYN.—*O. mauricensis* Gabb; Journal of the Philadelphia Academy of Natural Sciences, IV (n. s.), page 376.

The *O. mauricensis* does not appear to differ materially, if it differs at all, from the long forms of *O. virginica.* This species has been found fossil in New Jersey, Maryland, Virginia, North Carolina, and South Carolina.

A fossil form of the Faluns of Touraine, and in the vicinity of Bordeaux, is recognized as identical with the common living oyster of our Atlantic coast—*O. virginica* (Mém. Soc. Géol. de France, II).

PLIOCENE.

Ostrea atwoodi Gabb.

This species has already been noticed under the head of Miocene. Gabb was undecided whether to refer it to Miocene or Pliocene age.

Ostrea bourgeoisii Rémond.

(Plate LXXI, Fig. 1.)

Published in the Proceedings of the California Academy of Sciences, 1863, page 13, and by Gabb in Paleontology of California, II, page 33. It is referred to the Pliocene strata of California.

Ostrea heermanni Conrad.

This is also a reputed California species. It was published in the Proceedings of the Philadelphia Academy of Sciences for 1855, page 267; and in the Pacific Railroad Reports, V, page 326.

This species was originally described as probably Miocene (as probably from the same deposit which contained *O. vespertina*), and is given as such in Meek's Miocene List; but in the appended "Notes and Explanations" (page 26) it is stated that "Conrad now thinks his *Ostrea heermanni* probably a Cretaceous species." Carrizo Creek, Colorado Desert, where it was found, is Pliocene, according to Gabb; and the *O. heermanni* is accordingly given as a Pliocene species in Paleontology of California, II, p. 107.

Ostrea vespertina Conrad.

(Plate LXXI, Figs. 2, 3, 4.)

This form was published in the Journal of the Philadelphia Academy of Natural Sciences, II (n. s.), page 300; United States and Mexican Boundary Survey, I, page 160; and the Pacific Railroad Reports, V, page 325.

It is closely related to both *O. subfalcata* and *O. scalpturata*, and is possibly only a variety of one or the other of these species. It was originally described as Miocene, but the locality where it was obtained by Conrad, Carrizo Creek, Colorado Desert, is considered Pliocene by Gabb.

POST-PLIOCENE.

Ostrea conchaphila Carpenter.

This name is given as that of a California shell in the Catalogue of Mazatlan Shells in the British Museum (1857), page 161; but not figured.

There are nine specimens of an oyster in the collection of the Philadelphia Academy, marked "*O. conchaphila*, Cpr.," from the post-Pliocene of San Diego and False Bay; but whose determination the same may be I am unable to state. The *O. conchaphila*, as far as I know, is not stated to be fossil by any paleontologist. Some of the above specimens are undistinguishable from recent specimens marked *O. lurida* Cpr., also in the Academy collection, which is stated to be fossil by Newberry and Gabb. It therefore appears to me that the specimens marked *O. conchaphila* are more likely to be *O. lurida*, although their characters do not exactly agree with Carpenter's description of the latter species.

Ostrea fundata (Say ?) F. S. Holmes.

Post-Pliocene Fossils of South Carolina, p. 11. I have seen no specimens of this species.

Ostrea gallus Valenciennes.

Figured without description, Voyage de la Vénus; Atlas de Zoölogie, Plate 21. California. A recent species.

SYN.—*O. cerrosensis* Gabb; Paleontology of California, II, page 35. Cerros Islands.

As stated by Gabb, Paleontology of California, II, page 106, *O. cerrosensis* is in all probability identical with *O. gallus*, which, as figured, is about twice the size of the California fossil. A fossil from the late Tertiary of Peru, received from Professor Raimondi, which is considered by Gabb as the equivalent of his *O. cerrosensis*, is about the size of the living species, and undistinguishable from it.

Ostrea lurida Carpenter.

(Plate LXXII, Figs. 2, 3.)

This living species is mentioned as fossil in the Pliocene of California in Mollusks of Western North America (Smithsonian Miscellaneous Collections, 252), page 305. It is not figured in that work.

SYN.—*O. edulis* Cooper (non Lin.) fide Carpenter, *loc. cit.*, page 85, — Gabb, Paleontology of California, II, page 106.

From Benicia. Fossil at San Pablo, according to Dr. Newberry (teste Carpenter, *loc. cit.*, page 306).

Ostrea veatchii Gabb.

(Plate LXXII, Fig. 1.)

This is another California species published by Gabb in Paleontology of California, II, pages 34, 60.

APPENDIX II.

A SKETCH OF THE LIFE-HISTORY OF THE OYSTER.

By John A. Ryder.

The oyster always presents a definite right and left side; a dorsal or upper, and a ventral or lower part of the body, and an anterior or head end to which the hinder extremity is opposed. Thus it will be seen that it resembles greatly many common animals, not only in the respects already noted, but also in that the right and left halves of the soft parts are, with the exception of the alimentary canal, repetitions of each other, so that, as in man and the higher animals, there is apparent in the oyster that likeness of opposite sides of the body which has been termed bilateral symmetry. While this symmetry of the soft parts is so evident, it is less palpable when we compare together the two valves or shells which inclose and protect the animal. In the natural beds the left valve is usually undermost or inclined to be so, but in the crowded banks the shells, as growth proceeds, tend to assume a vertical position. The left valve is also more concave or hollowed out internally than the right one, which is often very nearly flat. In the European oyster (*Ostrea edulis*) both valves are much flatter than in the American and Portuguese (*O. virginica* and *O. angulata*); in the former the muscular impressions are also very nearly pyriform and colorless, while in the two latter they are usually more nearly kidney-shaped and deep purple in color. The average size of the American and Portuguese is also much greater than that of the common European species, and both the former grow much more rapidly than the latter.

Fig. 1, Plate LXXIII, represents an American oyster which has had the right valve and the most of the mantle of the right side removed, in order to show the soft parts in position as they lie on the left one. The head end of the animal lies close against the hinge *h*, or the point where the two valves are firmly joined to each other by a dark-brown, crescent-shaped, elastic body, *l*, known as the ligament. This ligament, while it serves to attach, also tends, because of its elastic properties, to separate the valves from each other at their broader, free extremities. In life, this separation of the valves at their wider free borders admits of the ready passage of water inwards to the gills *g*, and of food to the mouth *m*, while it also allows the water which has passed through the gills to escape by way of the wide cloacal space *cl*, carrying with it in its current the fæces from the vent or anus *v*. The tendency to separate the valves, inherent in the ligament, is balanced by the adductor muscle *M*, which upon the

slightest intimation of external danger forcibly contracts, closing the free edges of the valves tightly. The dark-purple scars near the centers of both valves, and vulgarly supposed to indicate the position of the heart, are simply the areas covered by the attachment of this adductor muscle, which is composed of a vast number of extremely fine muscular fibers, which collectively pass straight across the space between the inside of the valves, being firmly fixed at either end to the latter.

The muscle *M* when closely examined is found to be composed of bundles of fibers composed of still more slender fibrils, which are the contractile elements of this structure in the oyster. These fibrils are analogous to somewhat similar minute elements in our own muscles, to which muscular contractions are primarily due when evoked by some stimulus, such as that communicated by a very fine nerve fiber ending on the surface of the muscular elements. Two kinds of fibers are also found in the adductor; the first of which is the whitish, glistening variety found in the hinder crescent-shaped part of the muscle, and the second a paler, less lustrous, and grayish kind found in the darker and more anterior portion, as has been indicated in Fig. 1, by a different shading of the two muscular areas.

Another small muscle is found on either side of the body of the soft parts, an inch or a little more in front of the great adductor. Its position and size are indicated in Fig. 1, at *p'*, where it passes out through the mantle a little way behind and above the palps *p*, to be inserted into or attached to the inside of the valves a little distance behind the hinge *h*. This small muscle does not pass across the space between the valves like the great adductor, but its inner end is soon lost in the lower anterior part of the body mass; it is in fact a paired structure, the one on the right side of the body being a repetition of that on the left. In the American oyster its insertion on the inside of the valves is sometimes marked by a small purplish scar about one-eighth of an inch in diameter. This muscle has been identified with the pedal muscle of other mollusks by Dr. W. H. Dall, who was, I believe, the first to call attention to its existence.

As the oyster grows the insertions of both the great adductor and the pedal muscles enlarge and are extended progressively backwards on the inside of both valves and away from the hinge, as may be learned upon examining the muscular insertions on the valves of an oyster recently opened. There are no other points of attachment between the soft parts and the valves, except the opposite extremities of the great adductor and the small pedal muscles of either side. The soft parts are therefore in life adherent to the shell at four points.

The foregoing paragraphs fairly describe the mechanism of the shell and the manner of its relation to the soft parts, and also partially indicate the reciprocal physiological relationship subsisting between both.

The structure of the shell is laminar, or, in other words, it is composed of very numerous and thin parallel layers of calcic carbonate (chalk),

deposited in succession one upon the top of the other by the mantle in an organic horny matrix known as conchioline. When the surface of these layers is examined under the microscope the calcic carbonate is found to be arranged in minute polygonal blocks or prisms. The horny matrix of the shell, as well as the calcareous matter, is deposited by the mantle, and is primarily derived from the food and earthy matters swallowed by the animal.

The layers of calcareous matter, deposited as they are internally, as growth proceeds, project in succession past each other at the free edges of the valves and external surfaces of the shell, so that the successive deposits may be distinguished. It is also evident that deposition occurs to some extent periodically, which gives rise to the rough imbricated appearance of the edges of the layers which terminate on the outside of the shell. Moreover, the rate of deposition varies at different points around the margin of the shell, so that growth of the shell may take place more rapidly at one part of the margin of the valves than at another.

Cavities filled with fluid are frequently found in the calcareous valves of the oyster. They are usually shallow, and of no very great extent, and arise in consequence of the manner in which the calcareous matter is deposited by the mantle, the new layers not being laid down in immediate contact with the preceding ones, where the cavities are formed. Such cavities are also sometimes formed in consequence of the encroachment of mud between the valves, as shown at *x*, *x*, *x* in Fig. 1. In such cases the animal has sunken too deeply into the ooze, which then found its way into the shell while the animal had its valves parted when feeding. The mud which in such instances has insinuated itself between the mantle and shell is immediately covered by thin deposits of calcareous matter secreted by the border of the mantle. Inclosed in this way by calcareous deposits the included mud is rendered harmless to the soft and delicate structures of the inhabitant.

In Fig. 1, the back or dorsal side of the animal, it may be observed, extends anteriorly from *n* to *y*; the ventral or lower side reaches from *z* to *y*. The right and left sides of the animal are covered, in life, by an organ called the mantle, *mt*. (In the figure the mantle of the right side has been entirely removed, except a small triangular patch *mt'*, which is closely adherent to the front part of the body-mass.) This organ is thin; it is in fact a flat membrane, which is not attached to the shell anywhere except around the points where the ends of the adductor muscle *M* and the pedal muscle *p'* are affixed to the internal surfaces of the valves of either side. This organ, as may be seen from the figure, incloses, like the covers or lids of a book, the other soft parts, viz, the gills, body, and palps, which are in truth suspended between the two great right and left leaves of the mantle. The margins of the mantle-lobes of either side are joined together for only a short distance at the head end of the animal, or from *n* to *z*, forming a sort of hood over the mouth and great

fleshy lips or palps *p*, and closed above the latter. Posteriorly, at *y*, where the gills terminate, the mantle leaves of opposite sides are joined together by a narrow transverse membrane, which extends downwards and forwards forming the floor of the cloaca *cl* and the space between the ventral process of the body-mass *f* and the gills. This narrow membrane is perforated by four parallel rows of pores, *bp*, which lead down into the divided internal cavities of the gills.

The free margins of the mantle are fringed by two rows of short, purplish, extensible, and highly sensitive tentacles, which are supplied with nerves from the great nervous ganglion *pg*, on the lower side of the adductor *M*. The tentacles are protruded slightly beyond the edges of the valves when the animal is feeding, but they are quickly withdrawn upon any intimation of danger by the contraction of the slender, branching, muscular bundles which radiate outward in all directions through the mantle leaves of either side from around both of the insertions of the great adductor *M*. The radiating muscles of the mantle cross the marginal muscular fibers of the mantle border at right angles. They may collectively be called the pallial muscles.

The oyster is classed by naturalists amongst what are called lamelli branchiate mollusks, or those which tend to have the gills or branchiæ *g* developed as great flat parallel plates, or lamellæ, whence the name. In the oyster there are four gills, alongside of each other, which extend from behind the palps *p* to the point *y*. They are not really simple flat plates, however, as we learn upon examining them closely. They are really much more complex organs than might at first be supposed. Each gill is in fact composed of two rows of conjoined fleshy parallel filaments fused together at their edges and lower ends and joined above to the perforated fleshy membrane already alluded to. They are therefore in reality long and narrow hollow sacks. Their cavities are, however, subdivided by fleshy, transverse partitions at narrow intervals. The appearance of the gills, with their internal cavities, when cut across, is shown at *g'*, in Fig. 3, which represents a cross-section through the mantle, gills, and body of an oyster, enlarged about two diameters.

If we inspect the outer surfaces of the gills we will find that fine parallel ridges or ribs, with intervening furrows, extend vertically up and down, which give rise to a striated appearance on the surface of the branchiæ to the naked eye. Under the microscope these ridges in turn are found to be made up of still finer parallel ridges or ribs. A still more searching examination reveals the fact that there are rows of very fine pores between these ribs, which open from the outside into the cavity in the gill. On this account we are finally forced to regard the gills as sieve-like structures, a conception of them which is further justified by the fact that the gills have an exceedingly delicate internal skeleton apparently composed of a horny substance, the meshes of which are square or in the form of oblong squares, and around which the soft parts of the gills are built, and by which they are supported. It will be gath-

ered from the preceding account that these organs are quite different in structure from those of fishes, in which we find two rows of branchial processes, arranged like the teeth of a comb, supported at the outer margin of about five bony arches, with gill clefts or slits between the latter, which open outwards from the fore part of the sides of the throat. In the oyster the gills have no connection with the throat, and have, moreover, as already stated, the form of elongated sacks, with porous walls, with a row of large pores opening above into the cloaca *cl*, as shown in Fig. 1. The lateral pores between the ribs on the gills, and opening into the cavity of the latter, and these cavities in turn opening by way of the rows of large pores, *bp*, into the cloaca *cl*, permit the water necessary for respiration to readily pass through the gills, as indicated by the course of the arrows in Fig. 1.

The way in which the water is forced through them is, however, quite different from that observed in fishes, in which the water is pumped through the gills by the action of the mouth and gill-covers. In the oyster, on the other hand, fresh supplies of water are swept through the pores and internal cavities of the gills in an entirely different way, viz, by means of very numerous minute and slender processes with which these organs are covered. These processes, or *cilia*, as they are properly called, vibrate or swing to and fro many times per second, and more forcibly in one direction than in another, so that they set up a current of water in the direction of their most forcible vibration. This, in brief, is the means by which the water is swept through the gills of the oyster in a continuous stream, ministering to respiration or oxygenation of the blood of the animal in its passage through the branchial organs.

The blood of the oyster is normally colorless, and much more watery than in higher animals with red blood, in which the blood-cells or corpuscles are also discoidal or oval and flattened, while in the oyster they are nearly globular, as usually seen floating in the serum. They measure about one three-thousandth of an inch in diameter, but vary somewhat in size. They are in reality very small lumps of protoplasmic matter, provided with a nucleus embedded in their substance in an eccentric position. They undergo great changes of form when taken from the animal alive, and may live for four hours under the microscope, during which time they may be observed to slowly thrust out finger-like portions of their substance in various directions, and even move about slowly by means of a progressive flowing motion of their own glairy substance, much like those remarkably simple animals found in ponds and ditches, and known to naturalists under the name of *amœbæ*. In their movements, as watched under the microscope, two or more blood-cells of the oyster may even actually flow together and become confluent. Their function is in all probability of very much the same nature as that of the analogous corpuscles found in the vessels of higher animals, viz, to minister to respiration and the processes of

vital waste and repair. It is likely that they are formed indirectly from the nutritive matters which have been abscrbed from the food through the walls of the intestine and stomach; in fact, thin sections often show an abundance of similar corpuscular bodies in the tissues immediately adjoining the intestinal walls, the presence of which in such situations would seem to be most readily explained by the view here suggested. Whatever may be the mode of their origin, their structure and amœboid characteristics would indicate that as they are carried through the body of the animal by the blood current they take an all-important part in the processes of growth and renewal of structure and the expulsion of worn-out or effete materials, both liquid and gaseous.

The vascular system of the oyster is not very easy to describe briefly in an intelligible manner; in fact, it is not yet clearly understood in all of its details even by professed anatomists. The writer has, however, traced the principal vessels and their connections with the heart, body, and gills by a variety of methods, the results of which will be given here in outline.

The heart of the oyster is a much simpler organ than that found in man or the higher animals. It consists of three principal divisions or chambers, viz, a ventricle, partially divided in the middle line of the body by a partition or septum, and two smaller inferior chambers, one on either side, with darker walls than the ventricle. The relations of these parts to each other are shown in Figs. 1 and 2, at *ve* and *au*. The three chambers of the heart are lodged in a crescent-shaped cavity just in front of the adductor *M* and between the latter and the body-mass in front, as may be seen in Figs. 1 and 2. This cavity is closed on either side by a thin membrane, which is represented at *c*, in Fig. 1, detached at its anterior border from the body-mass and thrown back over the adductor muscle. It contracts much more slowly than the heart of higher animals, and even much more slowly than that of snails or gastropod mollusks. The normal number of beats of the heart of the oyster in life probably does not much exceed twenty per minute, if its pulsations are even so rapid as this. When fully distended the ventricle nearly fills the crescent-shaped space in which it lies, but falls far short of filling it when contracted. These two opposite conditions of dilitation and contraction of the heart are represented in Figs. 1 and 2.

The walls of the ventricle are very much thicker than those of the auricles, and are mainly composed of muscular fibers, which interlace with each other in various directions, and which contract and elongate simultaneously, so as to increase and diminish the capacity of the cavity of the heart alternately, thus constituting a veritable living pumping apparatus. This apparatus is rendered still more effective by reason of the two valves which are interposed between the ventricle *ve* and auricles *au*, the presence of which prevents the blood from flowing back into the auricles from the ventricle when the latter contracts.

These valves at the lower end of the ventricle open upwards, so that we may confidently infer that the blood of the oyster flows constantly in one direction, or from the auricles through the ventricle and from thence through the great posterior and anterior arteries *a* and *a′*, to be distributed to the opposite ends of the body.

The hindermost artery *a* carries fresh blood mainly to the great muscle *M*, while the anterior one *a′* carries blood to the body-mass anteriorly. After entering the body-mass at *a′* the anterior artery immediately divides and sends a dorsal branch *a′* forward, and a ventral branch *a″* downward and forward; these two vessels are shown cut across in the section represented in Fig. 3. The two main anterior arterial twigs give off many small branches at intervals which traverse the soft substance of the body, but in some portions there seem to be no true vessels, but rather irregular vascular spaces which in all probability communicate with the vessels just described. The tissue in which we find more or less evidence of the existence of irregular blood-spaces, is that indicated by the letter *c* in Fig 3, and is the tissue which envelopes all of the internal organs, extending even into the mantle and gills. This common supporting or connective tissue forms the walls of all the great arteries and veins throughout most of their extent, especially where these traverse the soft body-mass, palps, and gills. A few of the vessels have proper membranous walls, such as the branchio-cardiac vessels *br*, Fig. 1, which bring the blood back to the heart from the gills, mantle, and renal organs.

At the lower side of the body a large vein, the vena cava, *vc*, Fig. 3, receives the blood from the upper and anterior part of the body to convey it to the gills to be oxygenated before it is returned to the heart again. How the blood sent from the heart to the hinder part of the body is carried to the gills and back to the heart, the writer has not been able to make out clearly. There is also a system of vascular channels which traverse the adductor.

The arteries of the palps are superficial, and are shown in Fig. 1, but in the deeper, fleshy portions of the palps, definite vascular channels are replaced by irregular vascular spaces. Injections and sections also show that there are definite vascular channels in the mantle and gills, and in the former, especially when the oyster is very emaciated, these sometimes have very thick walls.

To sum up what we have stated regarding the course of the blood, we find that it passes from the gills to the heart, thence to the various parts of the body, and then directly to the gills again. It will be noticed that this is an arrangement very different from that found to obtain in fishes, where the heart receives the blood from all parts of the body, sends it through the gills, and then on directly to the various parts of the body. The difference between the circulation of the oyster and that of a warm-blooded, air-breathing animal with a four-chambered heart is still greater, from the fact that in such forms the heart receives the

blood from all parts of the body, sends it to the lungs, receives it again from the latter, to finally again send it off to the different parts of the body.

The food of the oyster is very various in character, as we find the remains of small crustaceans, mollusks, larval worms, crustacean larvæ, rhizopods, diatoms, &c., besides inorganic earthy and siliceous materials, in the stomach. It is probably omnivorous, as M. Certes has happily expressed it; the only condition which seems to be requisite in any organic body to fit it for food for this animal is that it shall be small enough to be passed through the wide but vertically much constricted mouth and throat. The great bulk of the food of the oyster, however, probably consists of minute marine larvæ, infusorians, and diatoms, and of these the latter, which are plants of microscopic size, are found in the greatest profusion. The diatoms have very delicately and beautifully sculptured siliceous cases, which encase the endochrome or living matter which becomes the food of the oyster. The empty siliceous tests of diatoms are often found in great numbers, mixed among the earthy matters and *débris* found in the intestine and stomach of the animal; in fact mineral and indigestible remains of many thousands of individual plants may sometimes be found in a couple of grains of the fæcal matters. The soft organic matter contained in the stony cases of these microscopic plants is rapidly dissolved by the digestive juices poured out by the liver, leaving behind the indigestible tests or cases which are carried out through the intestine along with the fæcal matters.

The most of the food of the oyster consists of minute, living, moving beings; this is the case even with the diatoms, which are minute vegetable organisms endowed with the power of movement. The same system of minute filaments which clothes the gills and ministers to respiration by sweeping the water through the latter in a constant current, is also the principal agent concerned in carrying the food of the oyster, which floats in the surrounding water, towards its mouth, as is indicated by the arrows below the palps in Fig. 1. When it has once reached the palps, the inner surfaces of which next to the mouth are provided with narrow ribs or ridges, which are thickly covered with cilia, it is swept down, or rather backwards, into the throat, from the point *m*, which marks the position of the mouth. The throat itself, however, as well as the entire alimentary canal, is clothed with vibrating cilia, which are the active agents in sweeping the refuse of the food and other ingestæ through the alimentary tract to expel it at the vent *v*.

In Fig. 2, Plate LXXIV, the course of the alimentary canal *i* is indicated, together with its relations to the liver *l*, in longitudinal median section of the fore part of the body. This sketch was taken from an actual dissection of a hardened specimen; the right lobe of the outermost palp and the soft parts of the right side have been removed in order to clearly display the course and arrangement of the alimentary canal. The parallel folds or ridges are shown on the outer surface of the inner palp or lip

p; it will be noticed that the ridges are wanting just a little below the level of the mouth. The mouth *m* opens by way of a short gullet or œsophagus into a very irregular cavity, which is the stomach. The intestine is continued from the posterior portion of the cavity of the stomach as a wide, somewhat irregular tube *i'* compressed laterally. In the lower part of this portion of the gut, and extending to its first bend, a singular opalescent, hyaline cartilaginous rod, the crystalline style, is lodged. Posteriorly, at the first bend of the intestine, a bluntly rounded finger-like ventral process of the body-mass *bm* envelops the latter. Beyond the first bend, the intestine *i*, as soon as it bends forwards again towards the head, becomes more nearly cylindrical, and is continued forwards over the gullet, bending down to the left side, and passes upwards, after making an open bend upon itself, obliquely backwards to end at the vent *v*.

The cavity of the intestine, along its narrow portion, is not really cylindrical, as may be seen in Fig. 3, representing a cross-section of an oyster, viewed from the anterior side, and taken from a specimen in a plane corresponding very nearly to the line *o* in Fig. 2. In this section the intestine is cut across twice, as shown at *i'* above and at *i* below the stomach. These sections show that the intestine proper has a peculiar crescent-shaped cavity, when cut straight across, which arises from the fact that one side of the wall of the intestine has been pushed inwards towards the other. This peculiarity characterizes the shape of the cavity of the intestine from its first bend to its termination at the vent.

The only glandular appendage of the alimentary tract of the oyster is the massive liver. It communicates with the stomach by means of a number of wide ducts with somewhat folded or plicated walls. The great ducts subdivide, and their ultimate ramifications terminate in a multitude of minute oval follicles, which are the effective agents in secreting the biliary and peculiar digestive juices. A thick stratum of these follicles surrounds the stomach except at its back or dorsal side. The extent or distribution of the liver *l* in the body-mass, and the way in which it is imbedded in the connective tissue *c* around the stomach *st*, may be inferred from Fig. 3.

The function of the so-called liver of the oyster is evidently digestive, and probably combines the action of a gastric, pancreatic, and biliary secretion. There are absolutely no triturating organs in the oyster for the comminution of the food; it is simply macerated in the glandular secretion of the liver and swept along through the intestines by the combined vibratory action of innumerable fine filaments with which the walls of the stomach, hepatic ducts, and intestine are clothed. There is no peristaltic action of the intestine and there are no annular muscles in its walls. The nutritive matters of the food are acted upon in two ways: first, a peculiar organic ferment or solvent derived from the liver reduces it to a condition in which it may be absorbed; secondly, in order

that absorption may be favored it is propelled through the intestinal canal, which is peculiarly constructed so as to present as large an amount of absorbent surface as possible.

The expulsion of effete matters in the oyster, beside fæcal matters, is accomplished by the respiratory system or gills and the organ of Bojanus. The first is concerned simply with the elimination of the gaseous products which are a result of the vital actions of the animal, the latter apparently with effete matters more or less nearly similar to the urinary excretions of higher animals. To what extent the liver may be excretory in function it is not possible to state.

The organ of Bojanus, a structure which appears to represent the kidneys of the higher animals, is an inconspicuous organ in the oyster as compared with its development in some other lamellibranchiates, such as the fresh-water mussels. M. Hoek, of Leyden, and the writer have been the first to definitely locate and describe this organ in the oysters of Europe and America. It consists of a crescent-shaped mass of tissue, indicated by the area *bj* in Fig. 1, lying on either side, just below the insertions of the adductor muscle *M*. In structure it is spongy and canaliculated and very possibly glandular. It lies close against the mantle on either side, and, in fact, extends somewhat into its substance. M. Hoek has traced the connection of this organ in the European oyster with the pericardiac cavity and the openings of the generative organs *s*, on either side of the ventral process of the body-mass *f*, shown in Fig. 1. The common openings of the generative organs and the organ of Bojanus will, therefore, probably have to be regarded as urogenital outlets.

The sexes are confined to distinct individuals in the American and Portuguese oysters, but the common oyster of Europe is clearly hermaphroditic, that is, the two sexes are more or less evidently combined in the same individual. The mature ova of the American and Portuguese species are of about the same size and measure about one five-hundredth of an inch in diameter, while those of the common European species are about one two-hundred-and-fiftieth of an inch in diameter. In the latter we may find the male and female elements developed side by side in the same ovarian follicles, but it also appears that there is a preponderance either of eggs or of spermatozoa developed in many individuals, so that some are even practically unisexual.

The reproductive organs are actively developed for only a comparatively short time, extending over a period of probably two or three months. In the region of the Chesapeake the most important spawning period seems to extend over the months of June and July, but considerable ripe spawn may be found even much earlier and later than this. Individual oysters may be occasionally found at almost any season of the year with spawn more or less far advanced or quite mature. It is not uncommon to find the reproductive organs far advanced in respect of functional development in the early spring months of

March and April. Upon examining large numbers of individuals at the same period, it will be found that while in many specimens reproductive activity has quite ceased, in others it is still in active progress. This variation is doubtless due to variations in the amount of food and to favorable temperature conditions, but it is in the highest degree probable, judging from the appearance of the spat, that comparatively few embryos ever develop so as to come to anything, except during the summer months.

The superficial extent of the reproductive organs is quite considerable, as may be inferred from an inspection of Fig. 4, which represents the soft parts of an oyster viewed from the left side, to display the ramifications of the generative ducts of the left half of the body, and the outlet below the muscle at *ov*. The generative tissue *Gen*, in this figure, is distributed over the surface of the body-mass as a thick, creamy white, superficial layer which covers the greater portion of the latter. It really consists of a multitude of little sacs or follicles embedded in the connective tissue, which open and pour their contents into the superficial branching ducts shown in Fig. 2. The mature products are poured out of the large oviduct *ov*, which empty into the water space above the gills, the current from which passes out of the shell by way of the cloaca *cl* (Fig. 1), which carries the generative products outward into the open water in the case of the American and Portuguese species. In these two species the impregnation appears to occur outside of the parent in the open water, where the eggs and milt encounter each other from individuals of different sexes, but in the common European species the unanimous testimony of observers is to the effect that the young are retained within the parent shell, adhering in masses to the mantle and gills, where they undergo a kind of incubation, prior to being set free to shift for themselves. This is a remarkable difference of habit, and one which would alone serve very well to discriminate the two forms from each other. The embryos of the hermaphroditic species are about twice as large in diameter as those of our native and the Portuguese species, owing to the fact that there is about the same difference in the size of the mature ova of the two types.

It is remarkable that we should find the reproductive organs of the oyster much more developed in some individuals than in others; in fact we may find them apparently wanting altogether in some specimens after the spawning season is over, or, on the other hand, forming, in the height of the season, a layer over the outside of the body-mass more than a fourth of an inch in thickness in some places. In an undeveloped condition the generative ducts and follicles form an open network which traverses the connective tissue. The relations of the generative tissues to the other organs is very well shown in Fig. 3, where *ge* indicates this layer moderately developed, as seen in a cross-section. Judging from the many observations made by the writer, it is evident that these organs diminish greatly in bulk, or disappear entirely after the spawning season

is over, to probably again develop to great proportions by the time the next spawning season arrives. The organs also vary with the size of the individual, and a large female American oyster may contain more than 100,000,000 ova; a small one, 3,000,000 to 4,000,000, or less. They begin spawning at one year old.

At a temperature of 75° to 80° Fahr. the period of incubation of the American oyster is only five to six hours, when the young commence to lead an independent active existence, which is in the most striking contrast with the permanent sedentary habit of the spat and adult conditions. In the European oyster the young are retained in the folds of the mantle and about the gills of the parent for apparently a much longer time, the length of which does not, however, yet seem to have been determined.

The young, when first hatched, are ovoidal in form, not much, if any, larger in bulk than the egg, and they have a slight depression on the back or dorsal side, which marks the position of the shell gland or first rudiment of the mantle organ properly so-called. Here, as development advances, the shell is formed as a very thin saddle-shaped structure, the right and left lobes of which grow in size with the development of the embryo. Soon these two halves of the larval shell become very convex and cover the soft parts of the young oyster on either side almost entirely; the mantle *m* and velum *v* alone projecting somewhat past their margins, as shown in Fig. 1 in the accompanying Plate LXXV, which represents a young American oyster in the larval or fry stage enlarged 250 times. The velum *v* consists of a cushion-shaped anterior projection of the soft parts, which bears two circles of long, very minute, thread-like appendages or cilia, which are incessantly vibrating, and which constitute the locomotive organs of the fry. The rapid movement of these filaments propels the young oyster through the water, and probably also carries minute particles of food to the mouth, situated immediately below the velum. The intestine and stomach are developed by this time, and there are also delicate muscles formed which retract the velum and draw the valves together.

A portion of the nervous system is developed in the center of the velum, which answers to the supraœsophageal ganglion *sg*, Fig. 1, Plate LXXIII (of the adult), which consists of a pair of knots of nervous matter, which lie above and at either side of the mouth, and which are connected on either side of the body by a commissure or nervous thread, with the larger hindmost ganglion *pg* below the adductor muscle. The mantle border is innervated from this hindmost nervous mass, and radiating threads pass out from it on either side in all directions to the edge of the mantle and tentacles. The nervous system of the fry or larvæ is much simpler than that of the adult, yet they are apparently sensitive to external stimuli, such as raps or blows struck on the table on which the microscope rests under which one is observing them.

The duration of the locomotive stage of development of the larvæ

has not yet been certainly determined for any one of the three species of which the development has been studied. In the case of the American species, however, it has been found by the writer that under favorable circumstances attachment of the fry probably takes place within twenty-four hours after fertilization. This appears to be effected by the border of the mantle of the fry, where it is deflected over the edge of the undermost valve, as represented at *m*, in Fig. 1 of Plate LXXV. The attachment is a close one to whatever surface the fry may fix itself, and at most, if there is a byssus developed, it is extremely short. The young, however, after attachment, continue to grow as larvæ, and have a very symmetrical shell, as shown, enlarged 96 times, in Fig. 3, in the plate. When the valves of the fry have acquired umbos the development of the spat shell begins, as shown in Fig. 4, in the plate. The spat shell is, however, different in its microscopical characters from that of the fry, since we find that in the spat shell, or in that formed after permanent fixation has been accomplished, the calcareous matter begins to be deposited in a tesselated or prismatic manner. The transition is a very abrupt one. The larval shell is homogeneous, but the calcareous material of which it is composed is laminar in arrangement. As soon as they are formed the beaks of the larval valves are invariably inclined upwards in the spat, as may be seen in Figs. 5, 6, and 7, viewed from above, and in Fig. 9, as seen from the side, in the plate. It is also a fact that the beaks of the larval shells are invariably directed horizontally in one way, as may be seen from the same series of figures.

For a considerable time the whole under surface of the lower valve of the spat remains flat and is cemented to the surface upon which it is fixed by its under side. It is only after it has grown to the size of from one-half to two inches across that its margin begins to bend upwards and become free. The cementing material seems to be the organic matrix of the shell which forms a perceptible layer on the outside of the valves, and which constitutes the epidermis or periostracum of the adult.

The history of the fixation of the common European oyster does not seem to have been very well worked out, but it is probably not very different from that of our own species. The young of the former, however, as taken from the beard, or mantle and gills of the parent, vary considerably in size, as may be inferred from an inspection of Fig. 2, in the plate, which represents four specimens enlarged 96 times, drawn to the same scale, in different positions, and taken from a preparation in the possession of the writer.

In order to show the rate of the growth of the spat or affixed stage of the oyster the following figures may be useful: That represented in Fig. 5, Plate LXXVI, is supposed to be not over twenty days old; that in Fig. 6 is known not to be over forty-four days old; that in Fig. 7, not over forty-eight; Fig. 8, seventy-nine; and Fig. 9, eighty-two days old. Fig. 10 represents an oyster of one summer's growth, collected from a wreck at Cape May, N. J., by my friend, Mr. John Ford. The preceding figures,

except the last one, are taken from spat which had fixed itself to and grown on tiles placed in the water in the vicinity of Saint Jerome's Creek, Maryland, during the summer of 1880. These tiles were placed in position at determinate dates so that the age of this spat was approximately known. The figures are of the natural size.

Some of the same lot of spat here figured was placed under favorable conditions, and, in the space of twenty-two months from the date of the fixation of the fry, had grown to a length of 3¾ inches, though the shell was still comparatively thin. From this fact it is fair to infer that in about twice that time, or in about four years from the egg, the oyster is approximately adult and marketable. In their best condition they are probably usually older than this, however.

The notion that the oyster is not edible during the so-called unseasonable months is not well founded; they may in fact be eaten at any season of the year, if fresh, without harm. In flavor, delicacy, and fatness the oyster is not as good in summer as in the colder months, but beyond this there is no great inferiority. The so-called fat of the oyster is not the spawn or engorged reproductive organs, but the connective tissue, indicated by *c*, in Fig. 3, Plate LXXIV. This connective tissue acquires a peculiar creamy whiteness during the winter months, together with a very considerable augmentation in volume, so that the mantle, especially that portion covering the body, becomes very much thicker. In summer, on the other hand, in consequence of the large amount of material which is used up in the development of generative products, this same tissue diminishes greatly in volume, and at the same time loses its creamy-white appearance and becomes transparent or translucent. At the same time, the minute structure of this same tissue acquires a somewhat different character from that observed in the fat condition, becoming looser or more areolar in appearance as seen in thin sections.

The waters in which oysters normally thrive are those where the bottom is pretty firmly fixed and not liable to sudden change. The creature belongs to what is called the littoral or shore fauna, and I doubt whether many extensive beds exist in waters more than 18 to 20 fathoms in depth. The range of the American oyster, according to Verrill, is from "Florida and the northern shores of the Gulf of Mexico to Massachusetts Bay; local further north off Damariscotta, Me., and in the northern part of the Gulf of Saint Lawrence, at Prince Edward Island, in Northumberland Straits, and Bay of Chaleur. Not found along the eastern shores of Maine, nor in the Bay of Fundy." In the Chesapeake, where all the conditions are favorable, the oyster is found more or less abundantly in the most of its tributaries, many of which are estuarine. The "coves" or inlets in the Chesapeake are largely of the same character and are affected on account of their great width, inconsiderable length, and free connection with the bay, by the tide to their very heads. In the great rivers, like the Potomac, which flow into the bay the oyster beds are also extensive and important industrially.

The sandy beaches of our coast are unfavorable in many places for the growth of oysters, although many important beds exist on our Atlantic coasts in favorable localities.

The water in which oysters exist may be almost entirely fresh, and it is doubtless a fact that in some cases, the water passing over the beds in certain situations at ebb tide, as in rivers, may be absolutely fresh, a fact noted by Semper in regard to the oysters of the Cumalaran River, at Basilan, south of Mindanao, in the East Indies. The hydrometer, in some places where there are extensive beds in the Chesapeake, stands at 1.007, and ranges on up to about 1.020 at the mouth of the bay, but in places still higher up the bay than that where our lowest hydrometric observation was made, the specific gravity of the water must be even very much less, so that in such places where fresh water is received from considerable streams from the land, and where oysters are known to exist, the water must often be almost or altogether fresh for hours together. The precise degree of saltness of the water most favorable to the growth of the oyster has not been determined, but to judge from the circumstance that most of the oysters which go to supply our markets come from the great bays, rivers, and estuarine tributaries of the coast it is fair to infer that such waters, which almost always have a less specific gravity than those of the open sea, are the natural home of this mollusk.

American as well as the European oysters sometimes acquire a peculiar greenish color in certain parts of the body, especially the gills and ventricle of the heart. These are always the first to be affected. A very careful investigation made by the writer has resulted in showing that it is the minute blood-cells which become tinged with a green coloring matter, and that they then tend to lodge in the heart and gills in great numbers, thus giving rise to the green appearance. The coloring matter, whatever it may be, is harmless, as it has never been shown that it is a poisonous compound of copper, as has been erroneously supposed. It is very possibly derived from some vegetable coloring principle taken with the food, or it may possibly be an abnormal product of the digestive process. It is equally certain that this green coloration is not due to the presence of a vegetable parasite.

Recent experiments have tended to show that it is not improbable that both the American and Portuguese oysters may be reared in very much the same way as fish are bred from their ova. The experiments of M. Bouchon-Brandely, in France, and of Colonel McDonald and the writer, in this country, show that such a method is probably feasible. The writer has shown that the eggs may be very expeditiously extracted from the oyster somewhat after the method employed in taking the ova from fishes. He has also devised a method of distinguishing the sexes apart, so simple that the distinction may be made without even the use of a pocket lens. The eggs and milt after the removal from the parent animals, may be poured together, in order that fertilization may

take place. After a few hours have elapsed, these embryos may be poured into suitable inclosures, into which the sea-water may enter and escape without carrying off the embryos themselves. In such inclosures in which tiles coated with lime have been placed, it has already been demonstrated that the embryos or fry will attach themselves to the tiles and become transformed into young spat. As many as four thousand have been found adherent to one tile, as a result of such experiments.

During the present season the writer has successfully reared the spat of the American oyster in a pond constructed on the premises of Messrs. Pierce and Shepard, near Stockton, Worcester County, Md. This pond was dug out of a salt marsh; its depth was three feet and a half. It was connected by a trench with Chincoteague Bay, adjoining. Into the trench a wooden diaphragm was tightly fitted and filled with sharp sand to filter the water passing into the inclosure, and to prevent the escape of the artificially-fertilized embryos of our native species, which were introduced into the pond at intervals during the month of July. In forty-six days after the commencement of this experiment we found spat measuring three-fourths of an inch in diameter attached to the old shells which had been put into the pond to serve as collectors. This experiment proves that artificial oyster culture is feasible in the United States, and that marsh lands may become valuable where the adjacent waters are of the proper density.

The shells of the oyster are very irregular in form, in fact, scarcely any two individuals are to be found which are precisely alike. The typical form of the shell of the American oyster is very well shown on Plates LXXVII and LXXVIII, and is in fact the form most desirable in the estimation of the grower and dealer. Other varietal forms are, however, met with which diverge pretty widely from this one, as may be inferred from the type represented in Plate LXXIX, where the lower valve is short and very deep. This second form is not a very usual one, but aptly illustrates one of the extremes of variation of the species. Another type now regarded as a variety of the common American oyster is represented on Plate LXXX, and was formerly supposed to be a distinct species under the name of *Ostrea borealis;* the name having reference to its more northern habitat. Its most characteristic conchological features are the deeply fluted valves; usually the lower one is the most deeply fluted, while the upper one is nearly smooth, but sometimes specimens are met with which have both valves very distinctly and quite deeply fluted. Of this form Verrill remarks, "Even the same specimen will often have the form of *borealis* in one stage of its growth, and then will suddenly change to the *Virginiana* style, and perhaps, later still, will return to the form of *borealis.* Or these different forms may be assumed in reverse order." Lastly, a type of oyster is met with in deep water or in crowded banks which has the valves abnormally elongated as represented on Plates LXXXI and LXXXII, and known as the raccoon or cat's-tongue oyster. This elongation of the valves

is due to crowding, and also to the sedimentation or silting of sand or earth between such individuals as grow closely together on the bottom. In the struggle for existence the animal is impelled to grow upwards from these causes in order to reach its food and the water necessary for respiration. Consequently the shelly deposit is laid down by the mantle mainly at the free ends of the upwardly directed valves, so that the latter grow only in length and not in width, thus giving rise to the extremely elongated type often met with. Such a form sometimes prevails over a whole bed, and the valves are often relatively very thin in consequence of the rapid growth which has been made in only one direction. In this form the animal or soft parts are also much elongated antero-posteriorly, so as to be quite different in shape as compared with the soft parts of an individual, such as that of which the shells are represented on Plates LXXVII and LXXVIII.

EXPLANATION OF PLATES.

PLATE XXXIV.

OSTREA PATERCULA Winchell. (Page 288.)

FIG. 1.—Interior view of the lower valve of the type specimen; natural size.
2.—Lateral view of the same specimen. After Winchell.

OSTREA ENGELMANNI Meek. (Page 289.)

3.—Exterior view of a lower valve; natural size.
4.—Interior view of another example.

CARBONIFEROUS AND JURASSIC.

PLATE XXXV.

GRYPHÆA CALCEOLA var. NEBRASCENSIS Meek & Hayden. (Page 290.)

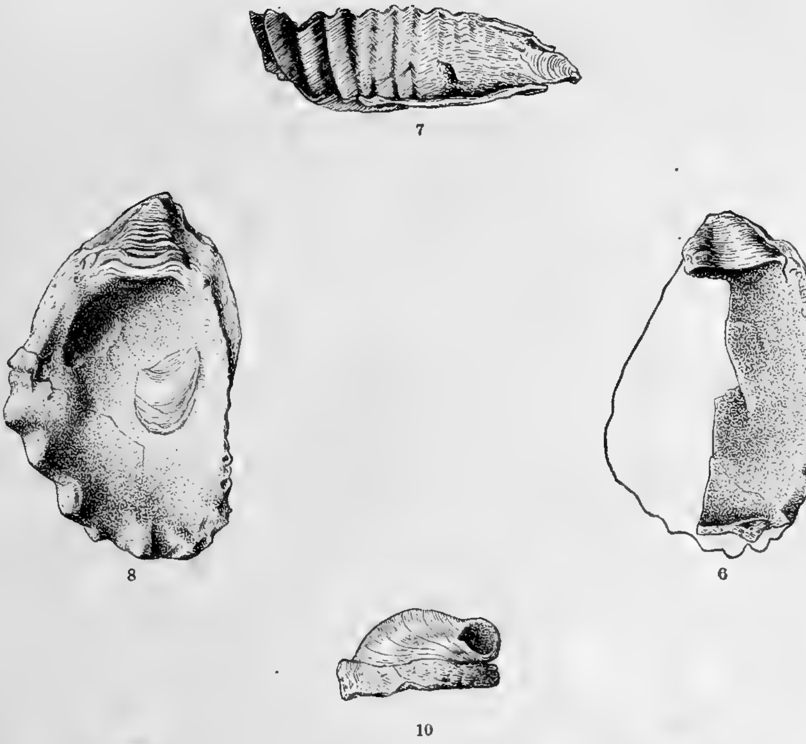
FIG. 1.—Exterior view of a lower valve; natural size.
2.—Lateral view of another lower valve.
3.—Interior view of the same example.
4.—Upper view of a small example.
5.—Interior view of an upper valve. After Meek.

OSTREA (ALECTRYONIA) PROCUMBENS White. (Page 290.)

6.—Interior view of a lower valve; natural size.
7.—Lateral view of the same specimen.
8.—Interior view of an upper valve.

OSTREA STRIGILECULA White. (Page 289.)

9.—Exterior view of a lower valve; natural size.
10.—Lateral view of the same specimen.
11.—Interior view of an upper valve.



JURASSIC.

3 INT——22

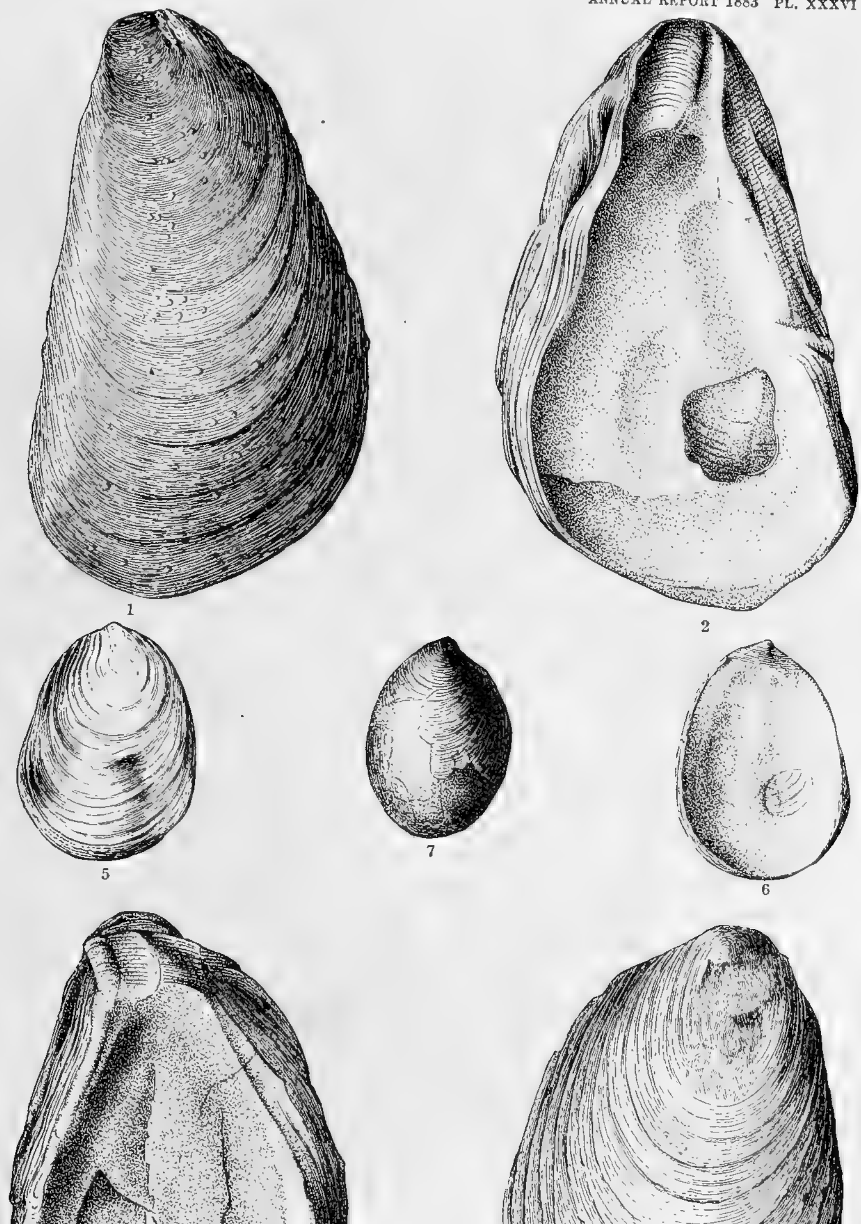
PLATE XXXVI.

OSTREA COALVILLENSIS Meek. (Page 293.)

FIG. 1.—Exterior view of an upper valve; natural size.
2.—Interior view of the same example.
3.—Exterior view of a lower valve.
4.—Interior view of the same example. After Meek.

OSTREA ELEGANTULA Newberry. (Page 295.)

5.—Exterior view of an upper valve; natural size.
6.—Interior view of the same specimen.
7.—Exterior view of a lower valve.



CRETACEOUS.

PLATE XXXVII.

OSTREA SUBSPATULATA Forbes. (Page 301.)

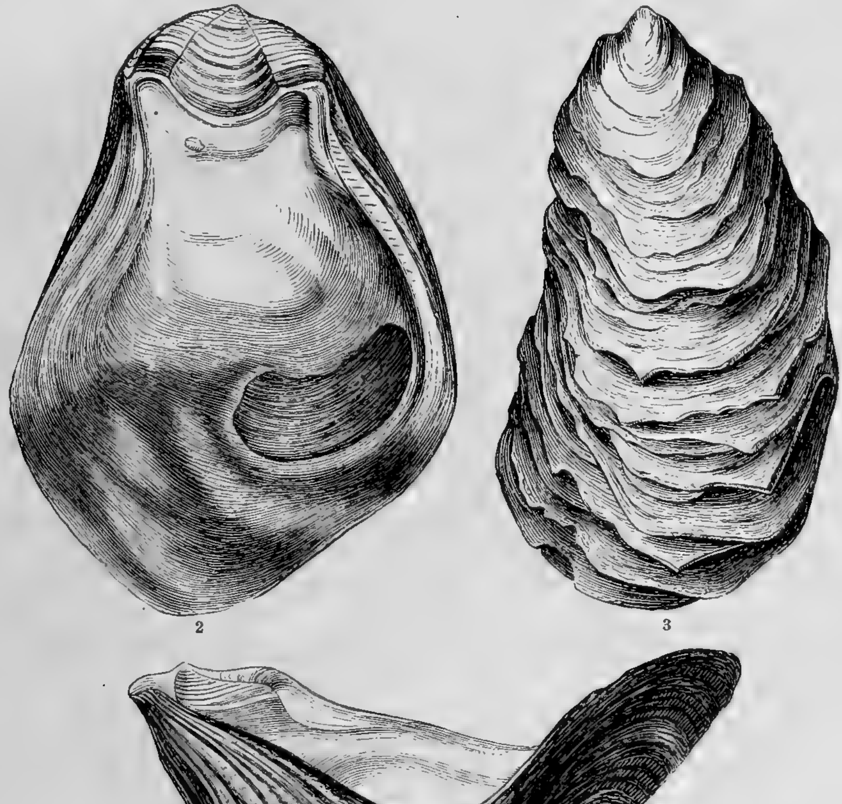
FIG. 1.—Lateral view of a separate valve; natural size.
2.—Interior view of the same example. After Forbes.

OSTREA CORTEX Conrad. (Page 294.)

3.—Exterior view of a separate valve; natural size.
4.—Similar view of another specimen. After Conrad.

OSTREA PLUMOSA Morton. (Page 299.)

5.—Upper view of a specimen somewhat distorted by pressure; natural size.
6.—Exterior view of the upper valve of another example.

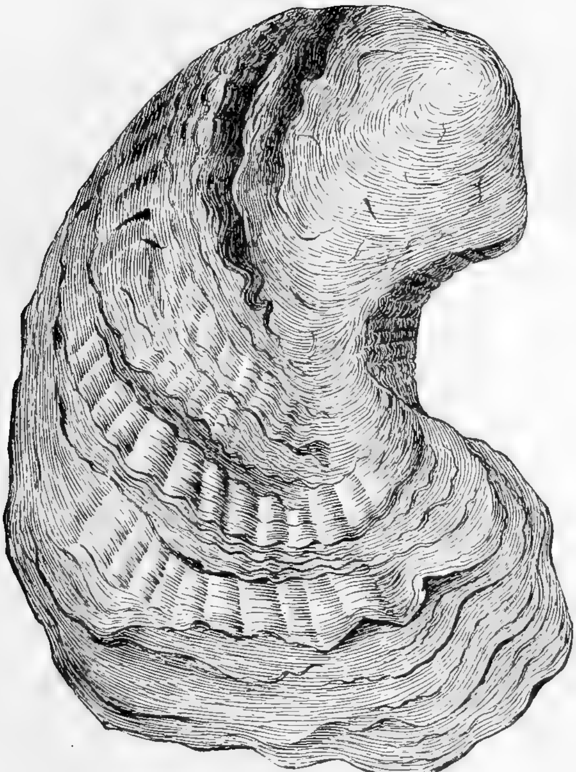


CRETACEOUS.

PLATE XXXVIII.

OSTREA MULTILIRATA Conrad. (Page 298.)

FIGS. 1, 2.—Exterior views of two different examples; natural size.



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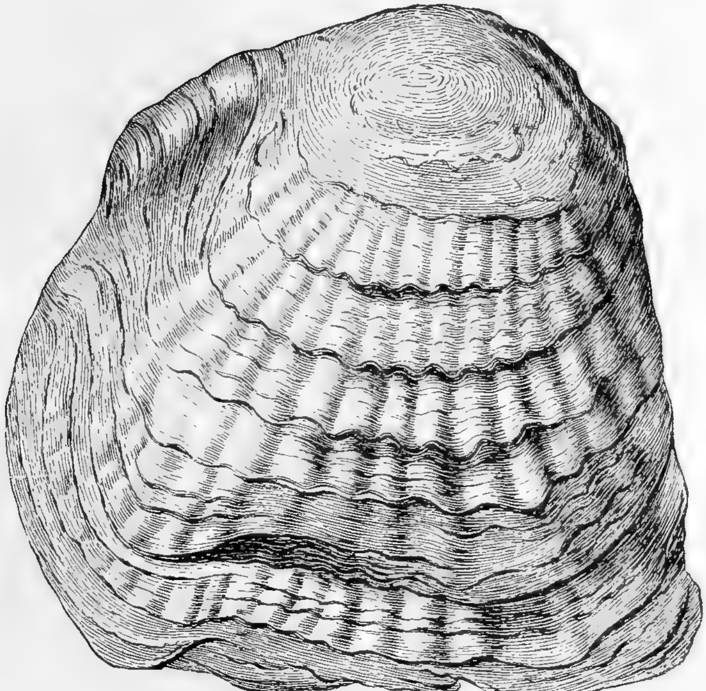

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CRETACEOUS.

PLATE XXXIX.

OSTREA FRANKLINI Coquand. (Page 296.)

FIGS. 1, 2. 3.—Views of three different examples; natural size. After Owen.

OSTREA ANOMIOIDES Meek. (Page 291.)

4.—Lower valve; exterior view; natural size.
5.—Similar view of an upper valve.

OSTREA BELLA Conrad. (Page 292.)

6.—Upper view; natural size. After Conrad.

OSTREA IDRIDENSIS Gabb. (Page 296.)

7.—Upper view; natural size.
8.—Interior view of an under valve. After Gabb.

OSTREA APPRESSA Gabb. (Page 291.)

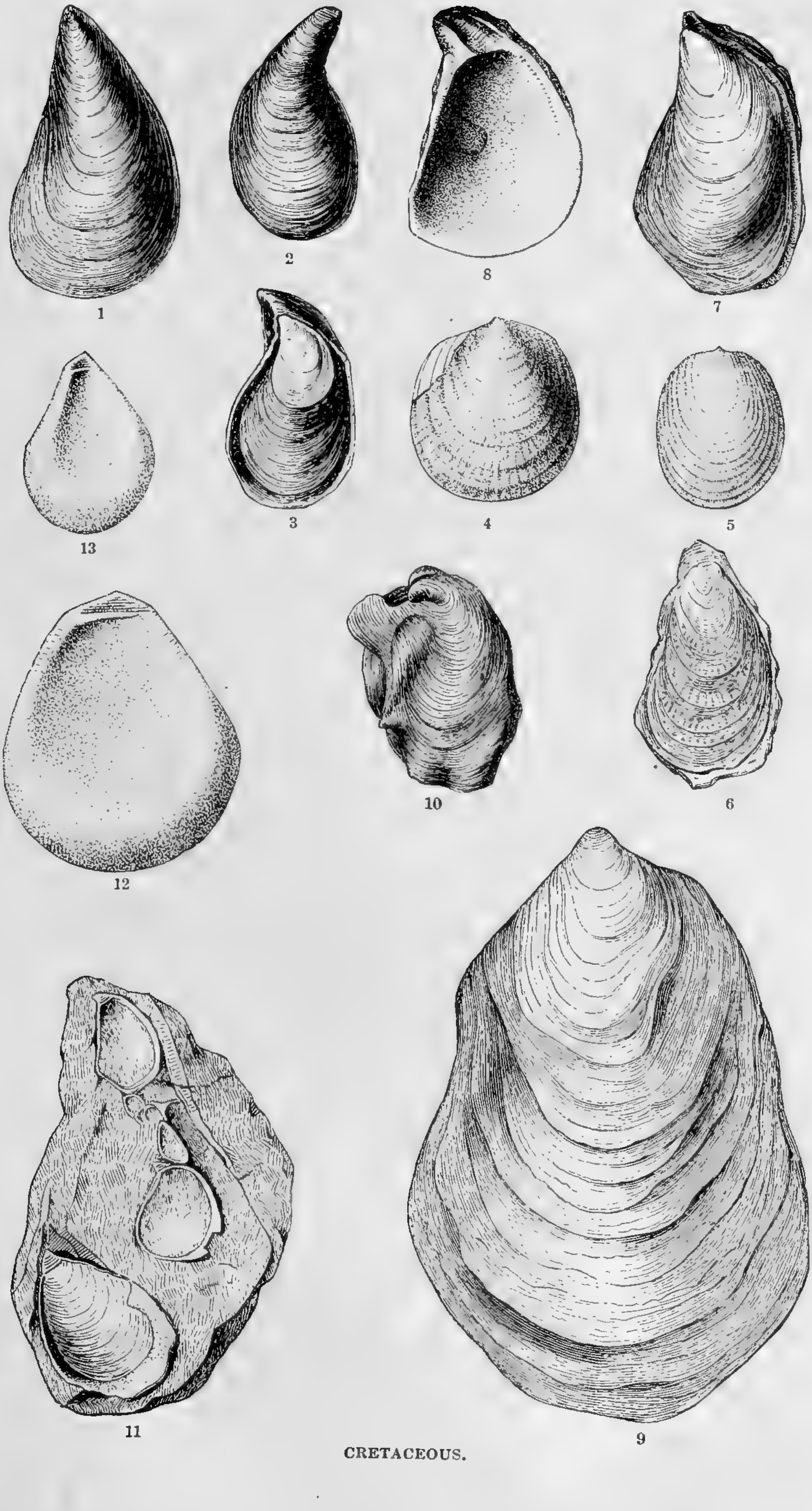
9.—Upper view; natural size. After Gabb.

OSTREA SUBALATA Meek. (Page 300.)

10.—Upper view; natural size. After Meek.

OSTREA CONGESTA Conrad. (Page 294.)

11.—Three small lower valves attached to a fragment of the shell of a large *Inoceramus*.
12, 13.—Interior views of upper valves. After Meek.



CRETACEOUS.

PLATE XL.

OSTREA DILUVIANA Linnæus. (Page 295.)

FIG. 1.—Lateral view; natural size. For other views see next plate.

OSTREA CRENULIMARGINATA Gabb. (Page 294.)

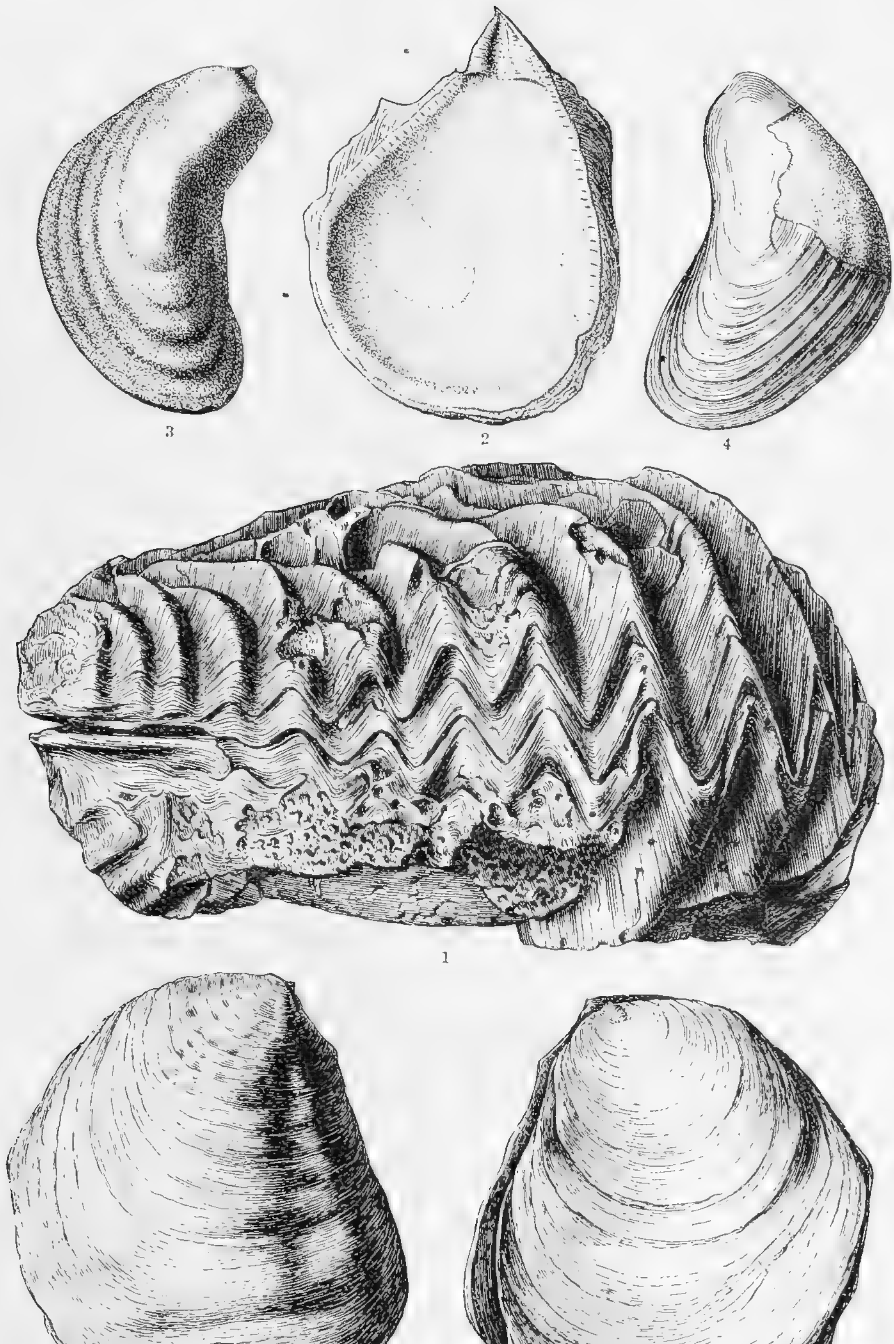
2.—Interior view of the lower valve; normal size. After Gabb.

OSTREA ROBUSTA Conrad. (Page 300.)

3, 4.—Opposite views of Conrad's type specimen. After Conrad.

OSTREA PRUDENTIA White. (Page 299.)

5, 6.—Opposite views of one of the type specimens; natural size.



CRETACEOUS.

PLATE XLI.

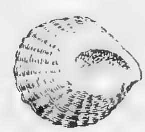
OSTREA DILUVIANA Linnæus. (Page 295.)

FIGS. 1, 2.--Exterior and interior views of the upper valve; natural size. For a lateral view of the same example see Plate XL.

OSTERA LUGUBRIS Conrad. (Page 297.)

3.—Exterior view of an under valve; natural size.

2



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CRETACEOUS.

PLATE XLII.

OSTREA SOLENISCUS Meek. (Page 300.)

FIG. 1.—Upper view of a small example; natural size. Fully adult examples are fully twice as long as this.

OSTREA (ALECTRYONIA) LARVA Lamarck. (Page 296.)

2–9.—Views of different examples, showing the wide variation of size and ornamentation. All natural size.

CRETACEOUS.

PLATE XLIII.

OSTREA CARINATA Lamarck. (Page 293.)

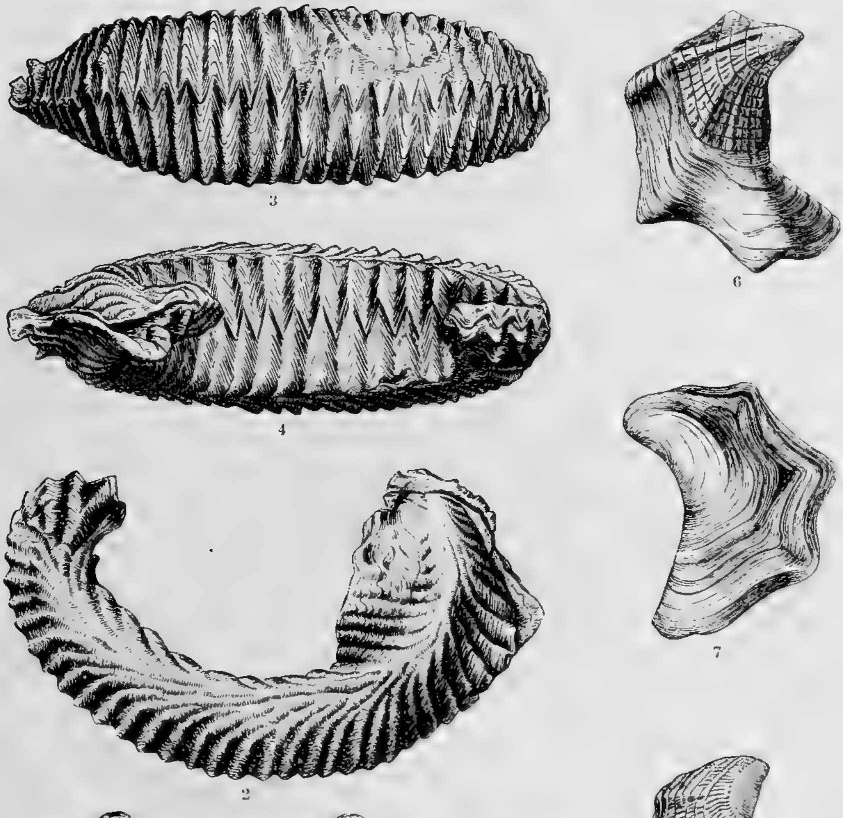
FIG. 1.—A large example; natural size. After Rœmer.
2, 3, 4.—Three different views of a smaller example; also from Texas.

OSTREA QUADRIPLICATA Shumard. (Page 299.)

5.—Exterior view of a lower valve having unusually prominent lobes; natural size.
6, 7.—Copies of Shumard's original figures.

OSTREA CRENULIMARGO Roemer. (Page 294.)

8, 9.—Copies of Roemer's original figures; natural size.

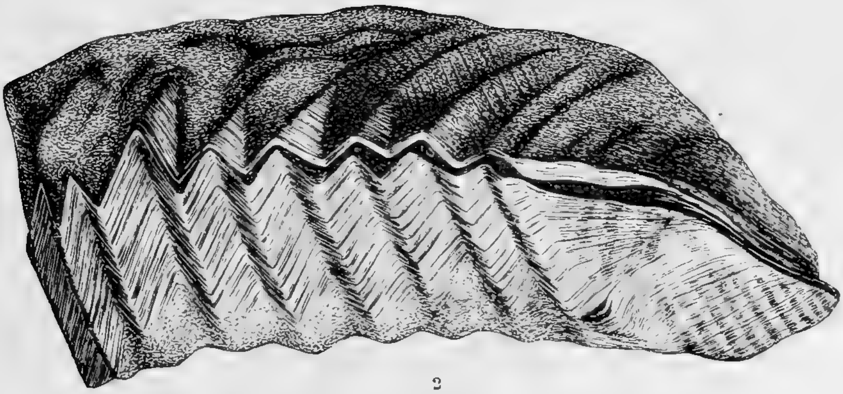


CRETACEOUS.

PLATE XLIV.

OSTREA BARRANDEI Coquand. (Page 292.)

FIG. 1.—Exterior view of the lower valve; natural size.
2.—Lateral view; both valves together. For other views see Plates XLV and XLVI.



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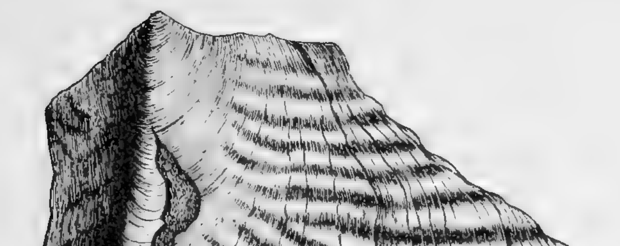


1

CRETACEOUS.

PLATE XLV.

OSTREA BLACKII White. (Page 292.)

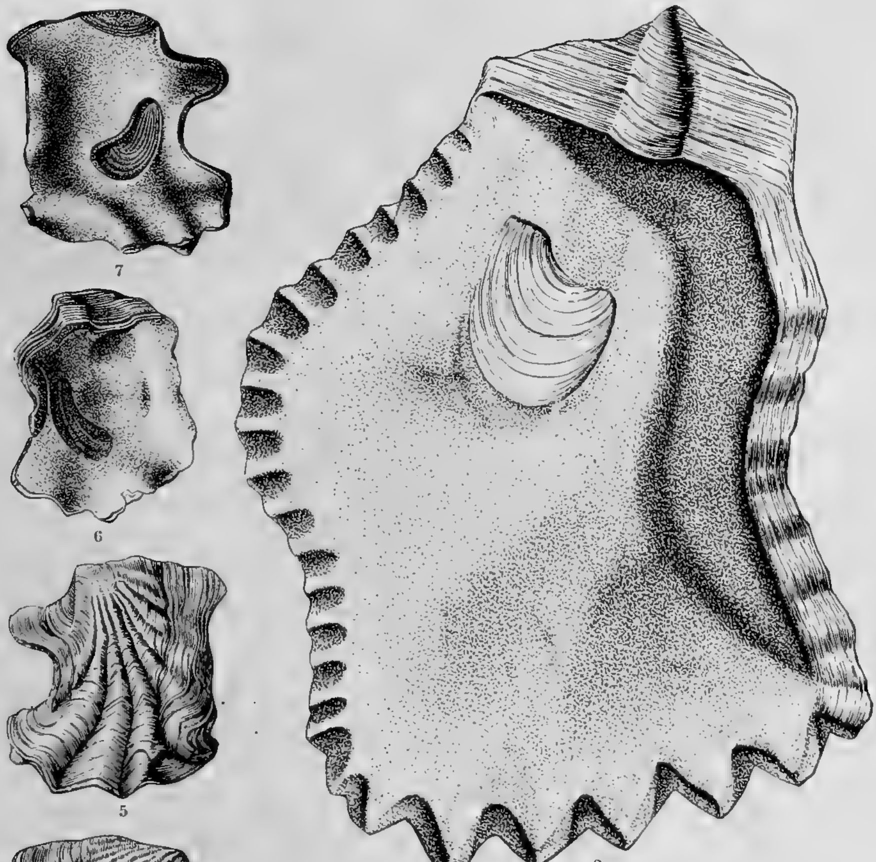
FIG. 1.—Upper view; natural size. For another view see next plate.

OSTREA BARRANDEI Coquand. (Page 292.)

2.—Interior view of the lower valve. For other views see Plates XLIV and XLVI.

OSTREA (ALECTRYONIA) SANNIONIS White. (Page 300.)

3, 4, 5.—Exterior view of three different valves; natural size.
6, 7.—Interior views of a right and left valve.



CRETACEOUS.

PLATE XLVI.

OSTREA BARRANDEI Coquand. (Page 292.)

FIG. 1.—Exterior view of the upper valve. For other views see Plates XLIV and XLV.

OSTREA BLACKII White. (Page 292.)

2.—Exterior view of the under valve. For the opposite view see Plate XLV.

2

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CRETACEOUS.

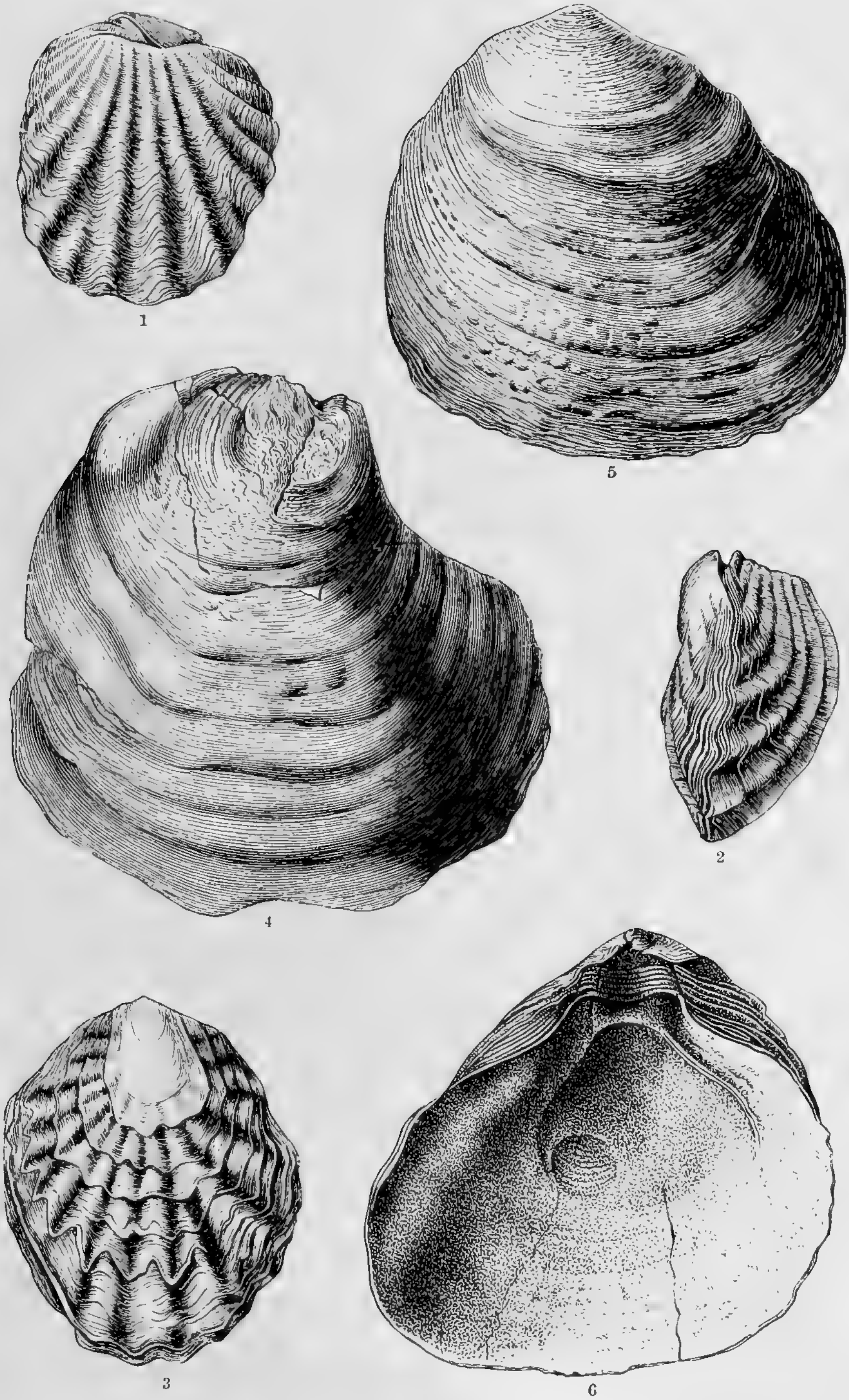
PLATE XLVII.

OSTREA BELLIPLICATA Shumard. (Page 292.)

FIG. 1.—Exterior view of the under side; natural size.
2.—Lateral view of the same example.
3.—Exterior view of the upper valve.

OSTREA PATINA Meek & Hayden. (Page 298.)

4.—Exterior view of an upper valve; natural size.
5.—Similar view of a lower valve.
6.—Interior view of the same example. After Meek.



CRETACEOUS.

PLATE XLVIII.

GRYPHÆA VESICULARIS Lamarck. (Page 303.)

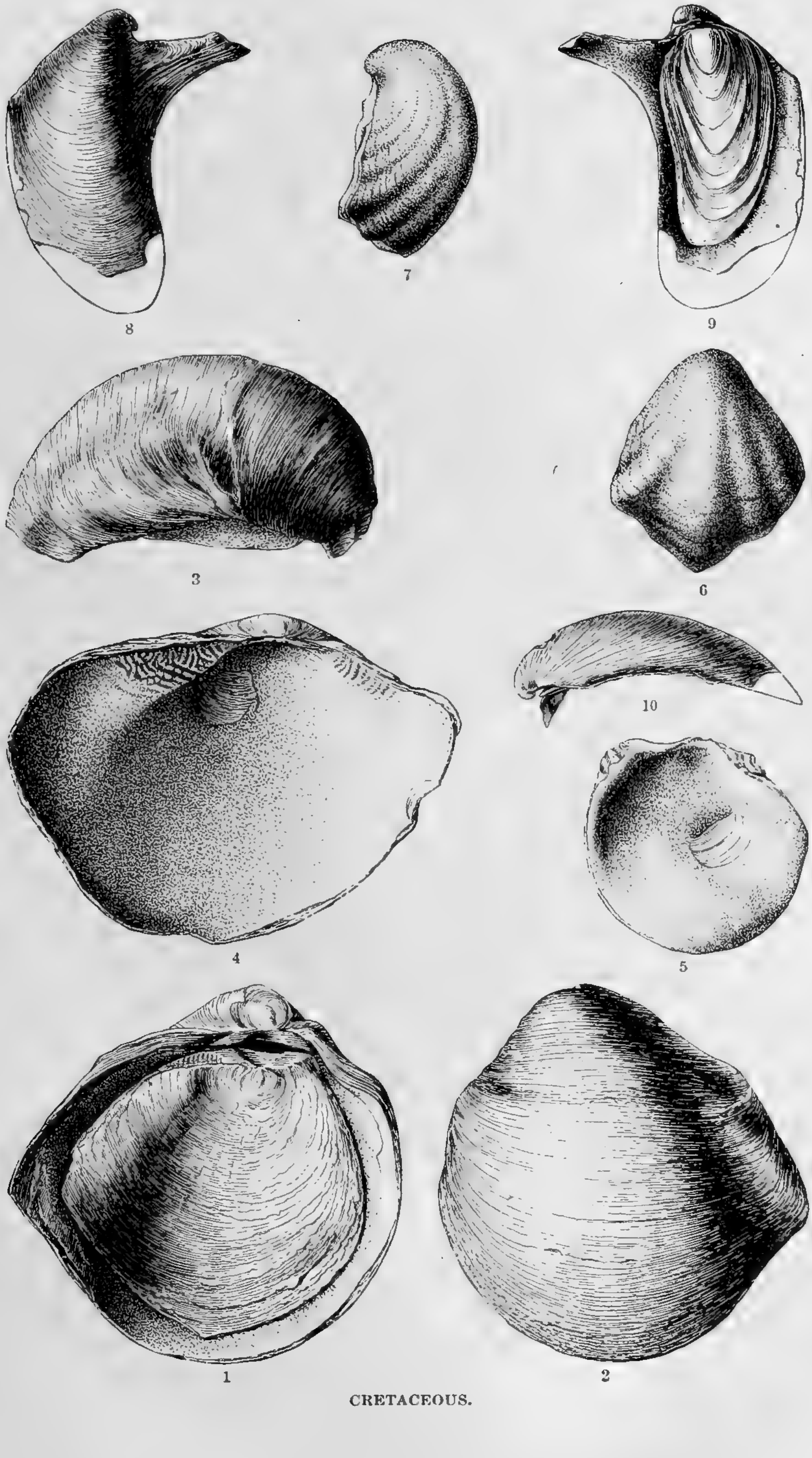
FIGS. 1-5.—Different views of separate valves; natural size.

OSTREA UNIFORMIS Meek. (Page 302.)

6, 7.—Two views of the lower valve of Meek's type specimen; natural size.

OSTREA VOMER Morton. (Page 302.)

8-10.—Different views; natural size.



CRETACEOUS.

PLATE XLIX.

GRYPHÆA PITCHERI Morton. (Page 302.)

FIGS. 1, 2.—Two views of an example of typical form, natural size.
3.—Interior view of the lower valve of a very large example.
5, 6.—Three views of the elongate variety to which Conrad gave the name *G. naria.* After Rœmer.

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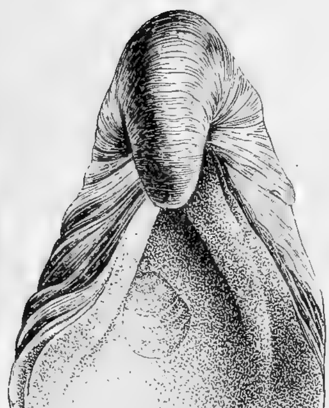


6

CRETACEOUS.

PLATE L.

EXOGYRA PONDEROSA Roemer. (Page 306.)

FIGS. 1, 2.—Upper and under views of an example of about half full adult size. After Roemer.

OSTREA TECTICOSTATA Gabb. (Page 301.)

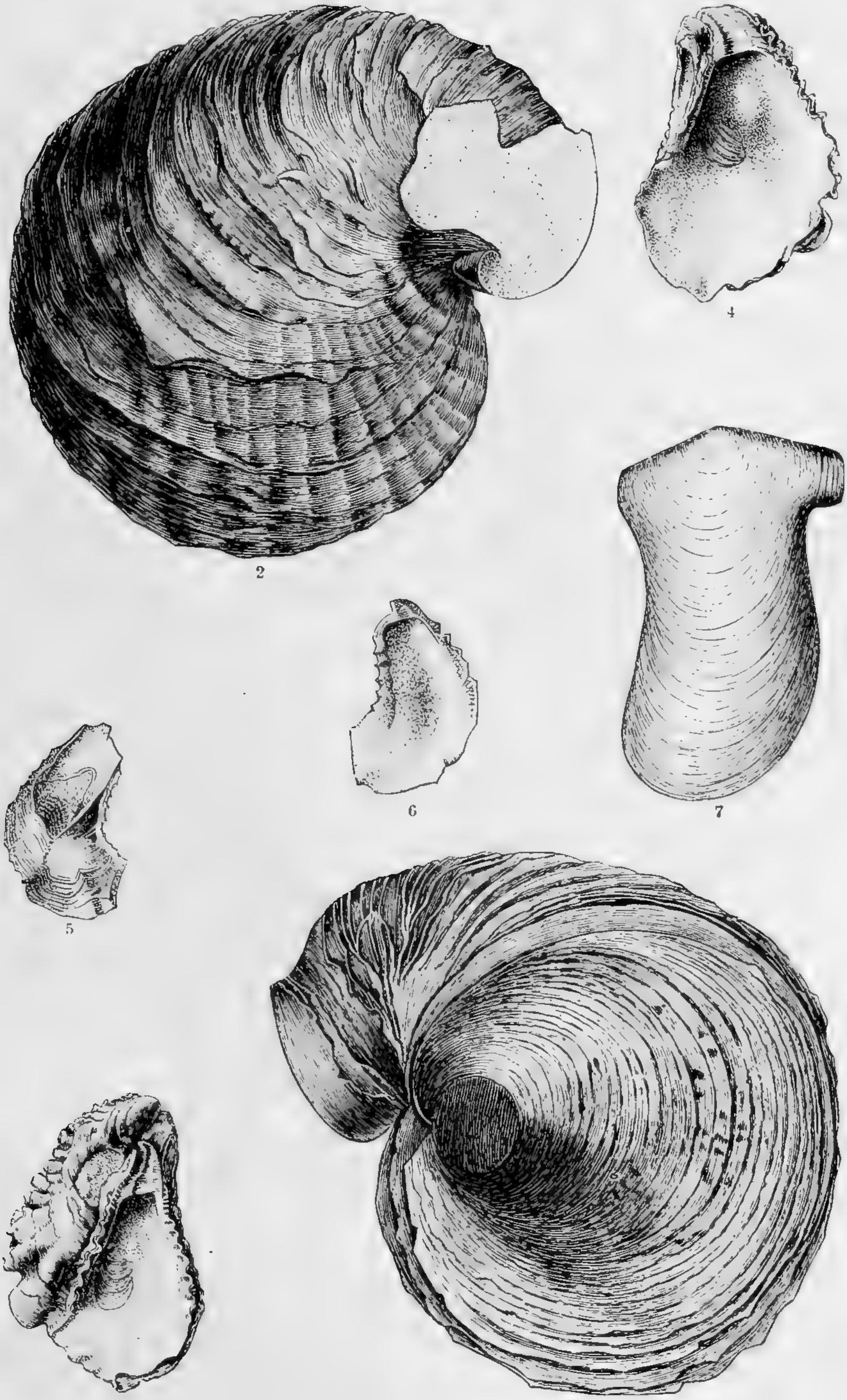
3.—A cluster of valves; natural size.
4.—Interior view of a lower valve.

OSTREA PELLUCIDA Meek & Hayden. (Page 296.)

5.—Exterior view of a lower valve; natural size.
6.—Opposite view of the same example.

OSTREA MALLEIFORMIS Gabb. (Page 297.)

7.—Exterior view of an upper valve; natural size. After Gabb.



CRETACEOUS.

PLATE LI.

EXOGYRA TEXANA Roemer. (Page 306.)

FIGS. 1, 2, 3.—Upper, under, and lateral views of a nearly adult example; natural size.
4, 5.—Interior views of the under and upper valves of the same example. After Rœmer.

CRETACEOUS.

PLATE LII.

EXOGYRA FORNICULATA White. (Page 305.)

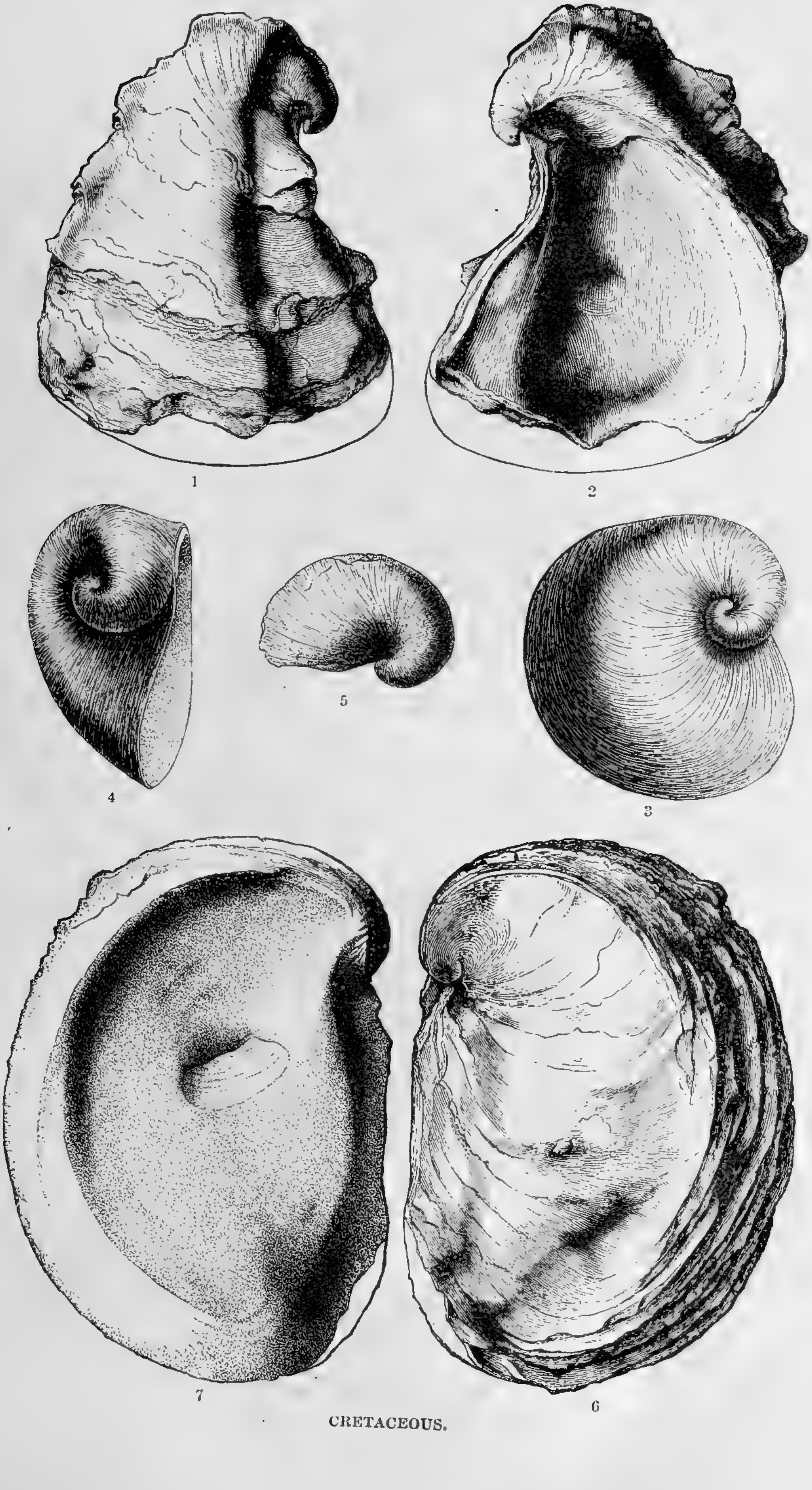
FIGS. 1, 2.—Exterior and interior views of the under valve; natural size.

EXOGYRA LÆVIUSCULA Rœmer. (Page 305.)

3, 4.—Two exterior views of the lower valve; natural size. After Rœmer.
5.—Lateral view of another lower valve.

EXOGYRA WINCHELLI White. (Page 307.)

6, 7.—Exterior and interior views of an upper valve; natural size. For views of the lower valve see Plate LV.



CRETACEOUS.

PLATE LIII.

EXOGYRA AQUILA Goldfuss. (Page 304.)

FIGS. 1, 2.—Upper and under views; natural size.

1

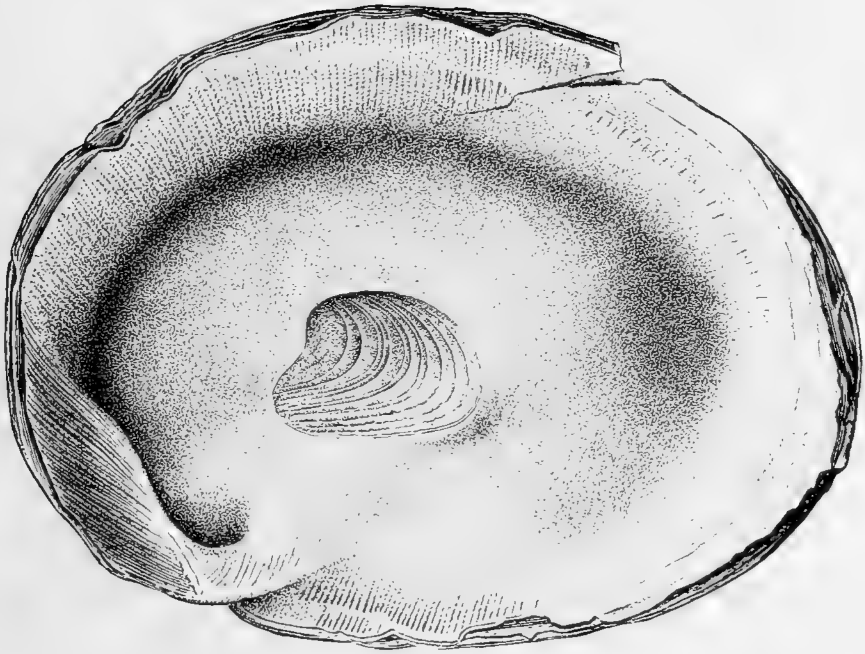
2

CRETACEOUS.

PLATE LIV.

EXOGYRA WALKERI White. (Page 307.)

FIGS. 1, 2.—Exterior and interior views of the lower valve; reduced to three-quarters of the actual diameter.



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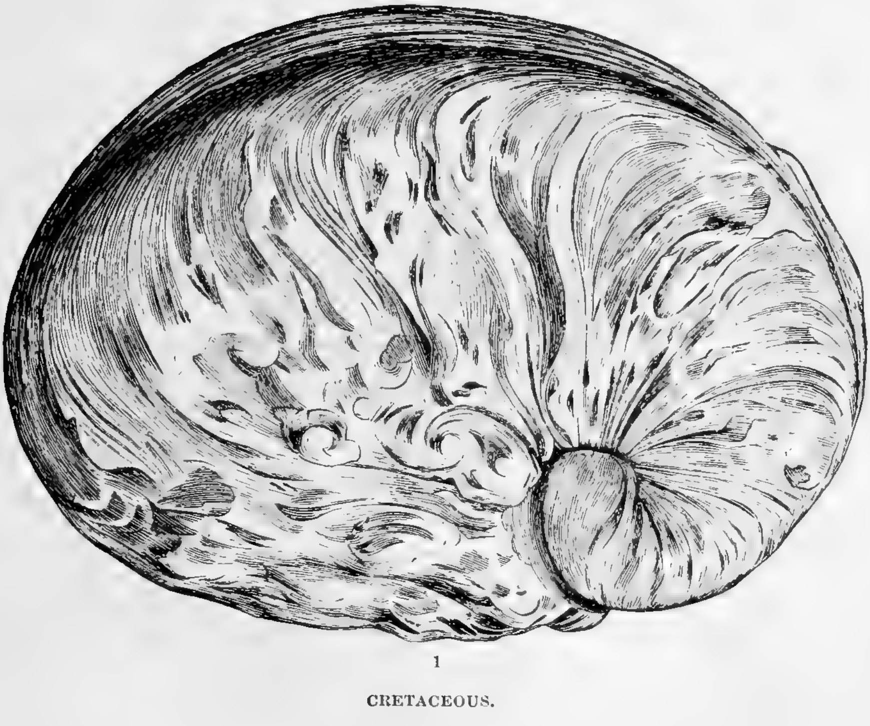

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CRETACEOUS.

PLATE LV.

EXOGYRA WINCHELLI White. (Page 307.)

FIG. 1.—Interior view of the lower valve; natural size.

2.—Lateral view of the same example. For views of the upper valve see Plate LII.

EXOGYRA PARASITICA Gabb. (Page 306.)

3.—Interior view of a lower valve; natural size.

4.—Exterior view of an upper valve. After Gabb.

EXOGYRA COLUMBELLA Meek. (Page 304.)

5, 6.—Two lateral views of a lower valve; natural size.

CRETACEOUS.

PLATE LVI.

EXOGYRA COSTATA Say. (Page 304.)

FIG. 1.—Lateral view of a lower valve; natural size.

2.—Exterior view of an upper valve. For other figures of this species see Plate LVII.

EXOGYRA ARIETINA Roemer. (Page 303.)

3.—Lateral view of a large lower valve, with the beak unusually long; natural size.

4.—A smaller example, showing the upper valve in place.

5.—Lateral view of the same example.

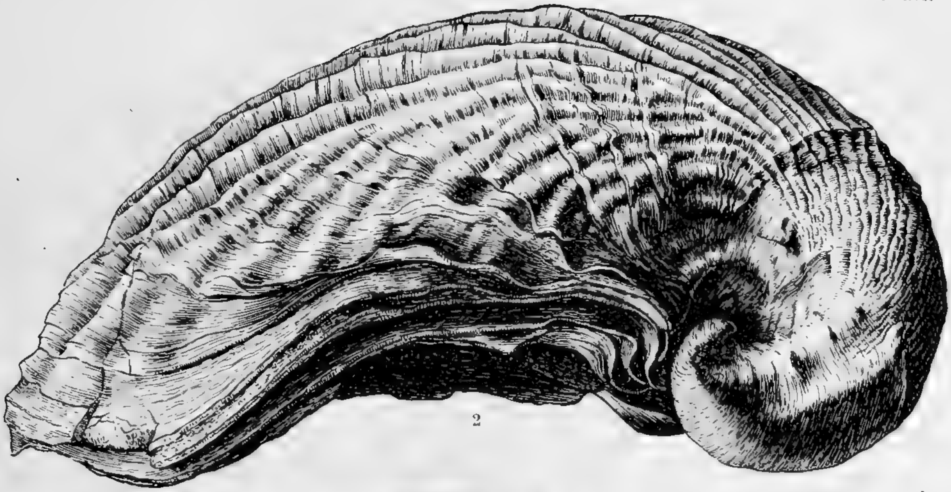
6, 7.—Copies of Say's figures of *Delphinula laxa* for comparison with *E. arietina.*

CRETACEOUS.

PLATE LVII.

EXOGYRA COSTATA Say. (Page 304.)

FIG. 1.—Exterior view of a lower valve; natural size.
2.—Lateral view of the same example.



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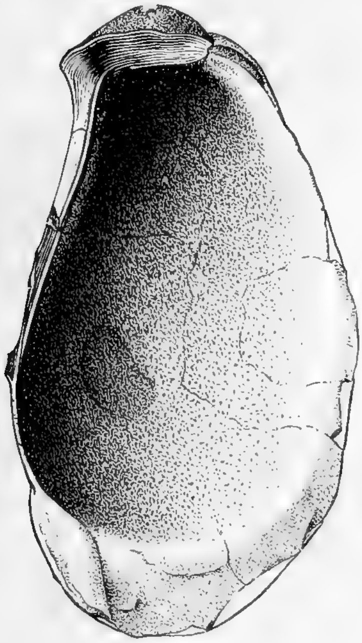
CRETACEOUS.

PLATE LVIII.

OSTREA GLABRA Meek & Hayden. (Page 307.)

FIGS. 1, 2.—Exterior and interior views of the type specimen; natural size. After Meek.

3, 4.—Similar views of a lower valve, from Colorado.



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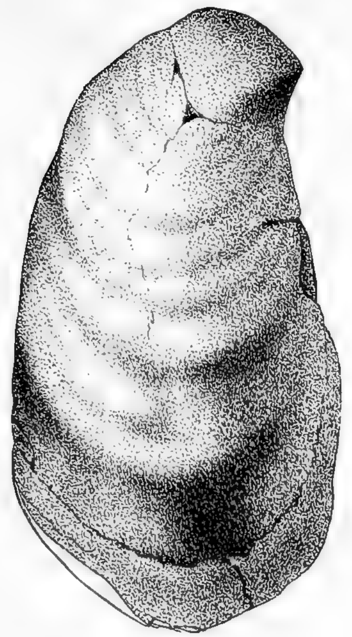

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LARAMIE.

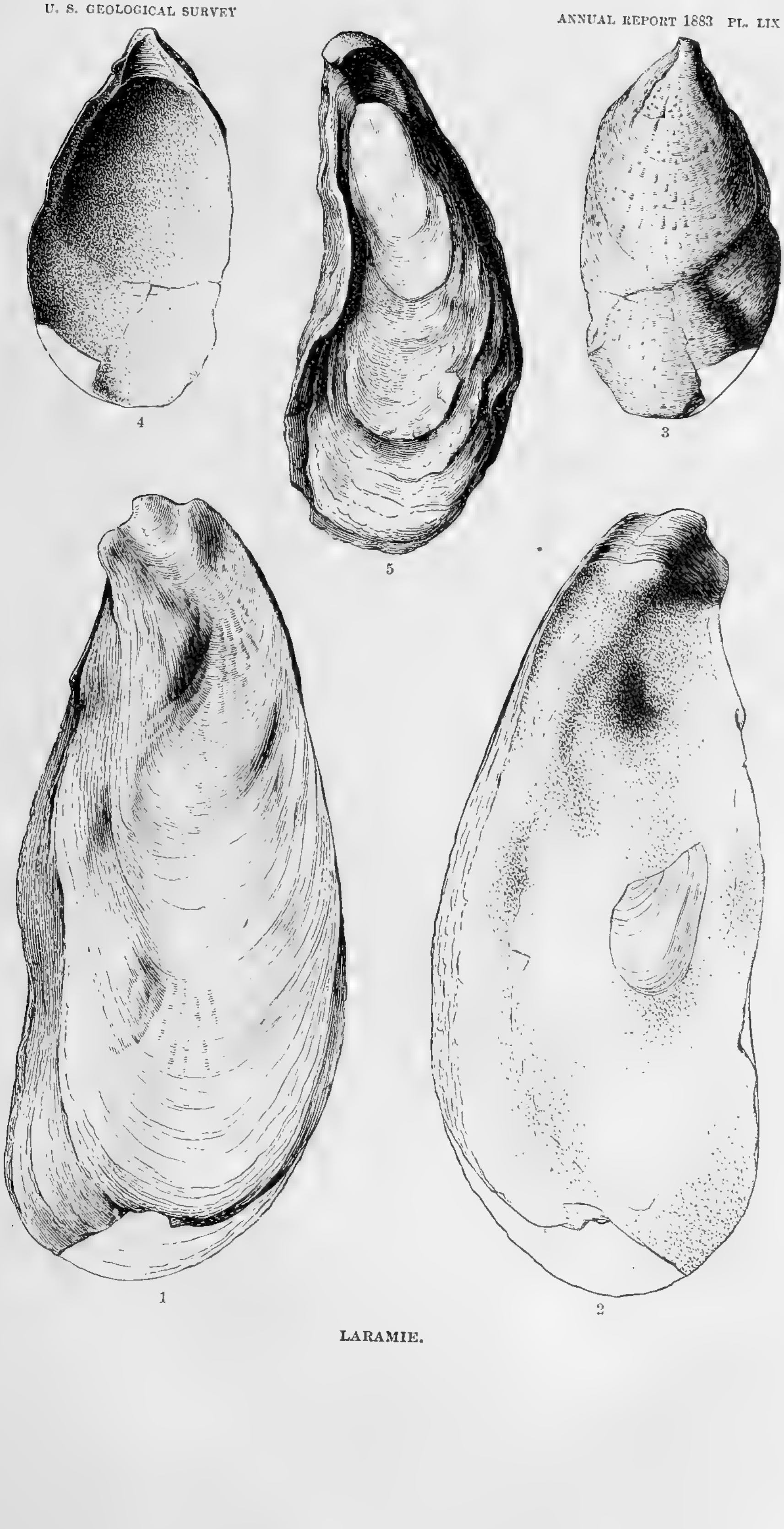
PLATE LIX.

OSTREA GLABRA Meek & Hayden. (Page 307.)

FIGS. 1, 2.—Exterior and interior views of an upper valve.

3, 4.—Similar views of the lower valve of the type specimen of *O. insecuris* White.

5.—Upper view of the type specimen of *O. arcuatilis* Meek.

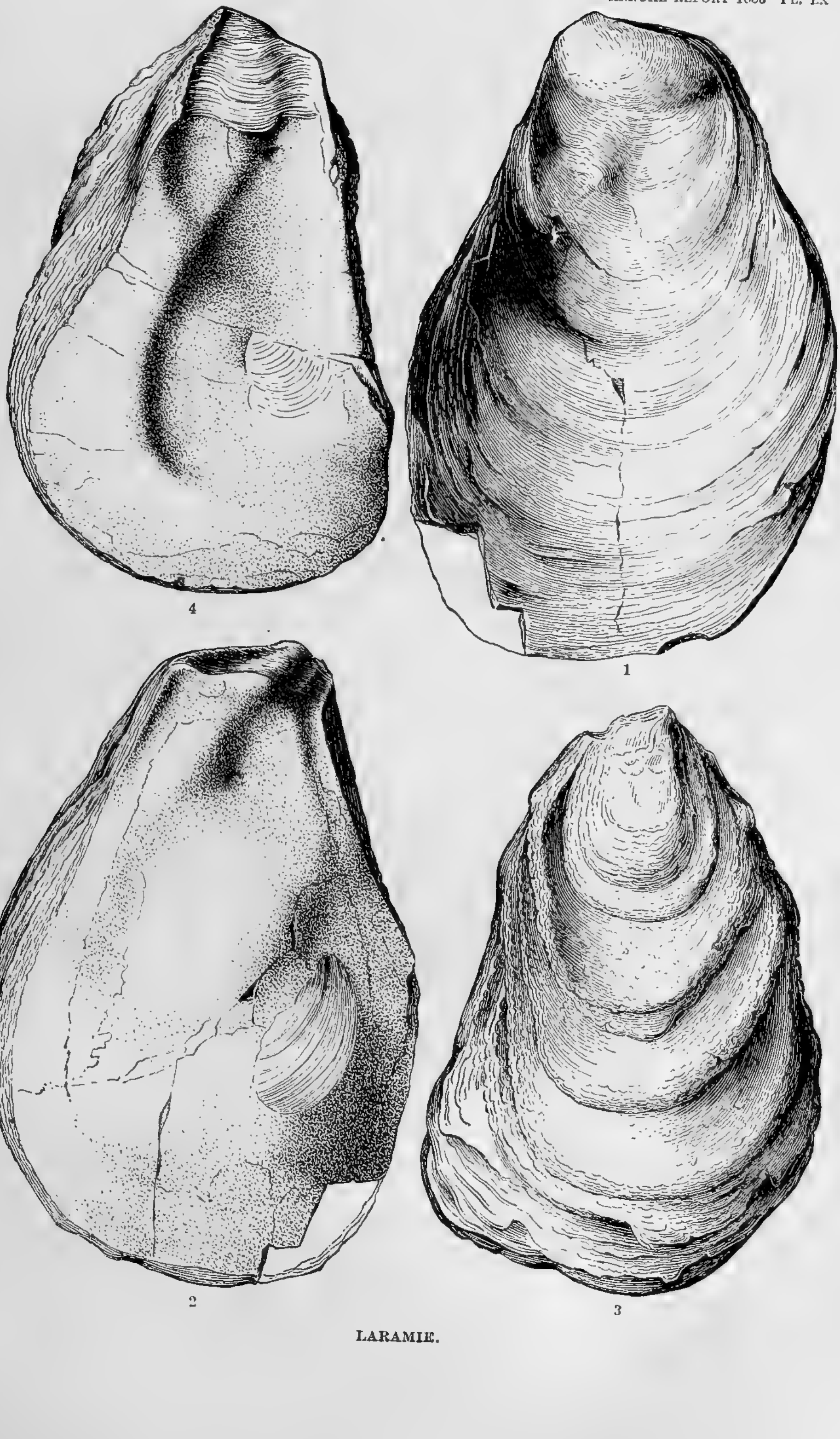


LARAMIE.

PLATE LX.

OSTREA GLABRA Meek & Hayden. (Page 307).

FIGS. 1, 2.—Exterior and interior views of a Colorado example.
3, 4.—Similar views of a Wyoming example.



LARAMIE.

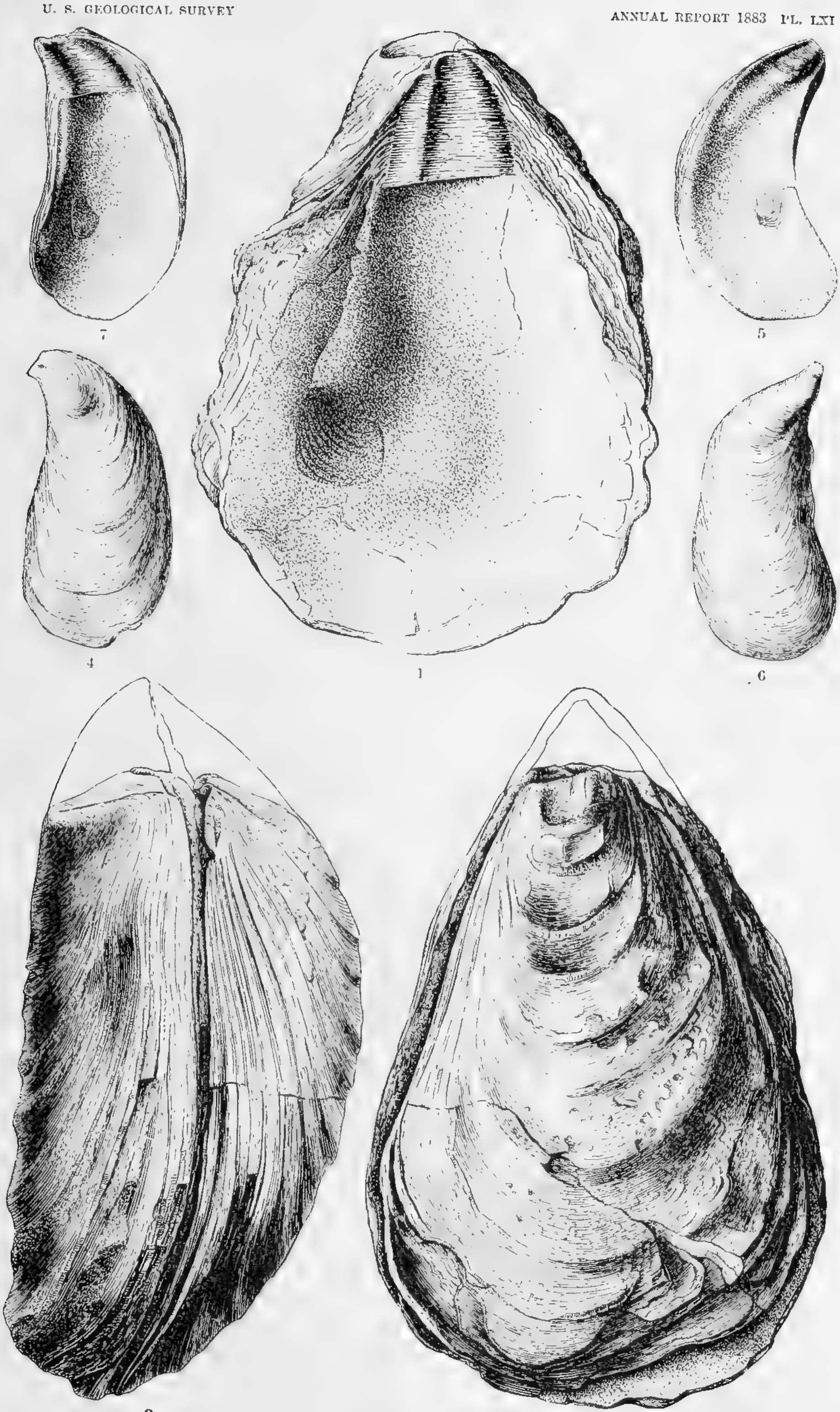
PLATE LXI.

OSTREA GLABRA Meek & Hayden. (Page 307.)

FIG. 1.—Interior view of a lower valve from Wyoming.
2, 3.—Upper and lateral views of a specimen from the state of Nuevo Leon, Mexico.

OSTREA SUBTRIGONALIS Evans & Shumard. (Page 308.)

4.—Exterior view of an upper valve; natural size.
5.—Interior view of the same example.
6.—Exterior view of a lower valve.
7.—Interior view of another lower valve.

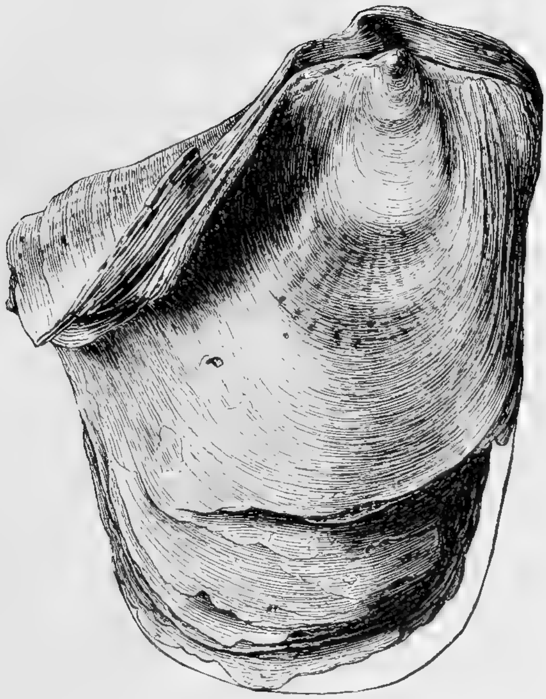


LARAMIE.

PLATE LXII.

OSTREA SELLÆFORMIS Conrad. (Page 311.)

FIG. 1.—Upper view; natural size. LXIII,
2.—Lateral view of the same example. For another view see Plate ~~XXX~~.



1

2

EOCENE.

PLATE LXIII.

OSTREA SELLÆFORMIS, Conrad. (Page 311.)

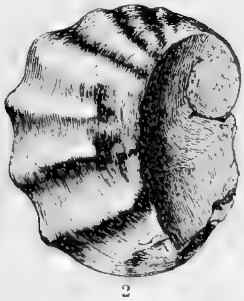
FIG. 1.—Under view of the example that is figured on Plate XXIX.

OSTREA VICKSBURGENSIS, Conrad. (Page 312.)

2, 3.—Exterior and interior views of a lower valve; natural size.

OSTREA THIRSÆ Gabb. (Page 311.)

4, 5, 6.—Exterior, lateral, and interior views of a lower valve; natural size.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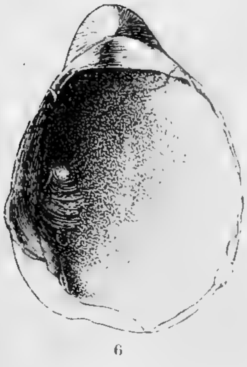
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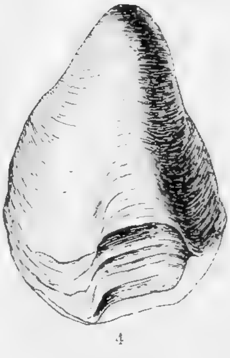

4

EOCENE.

PLATE LXIV.

OSTREA DIVARICATA Lea. (Page 310.)

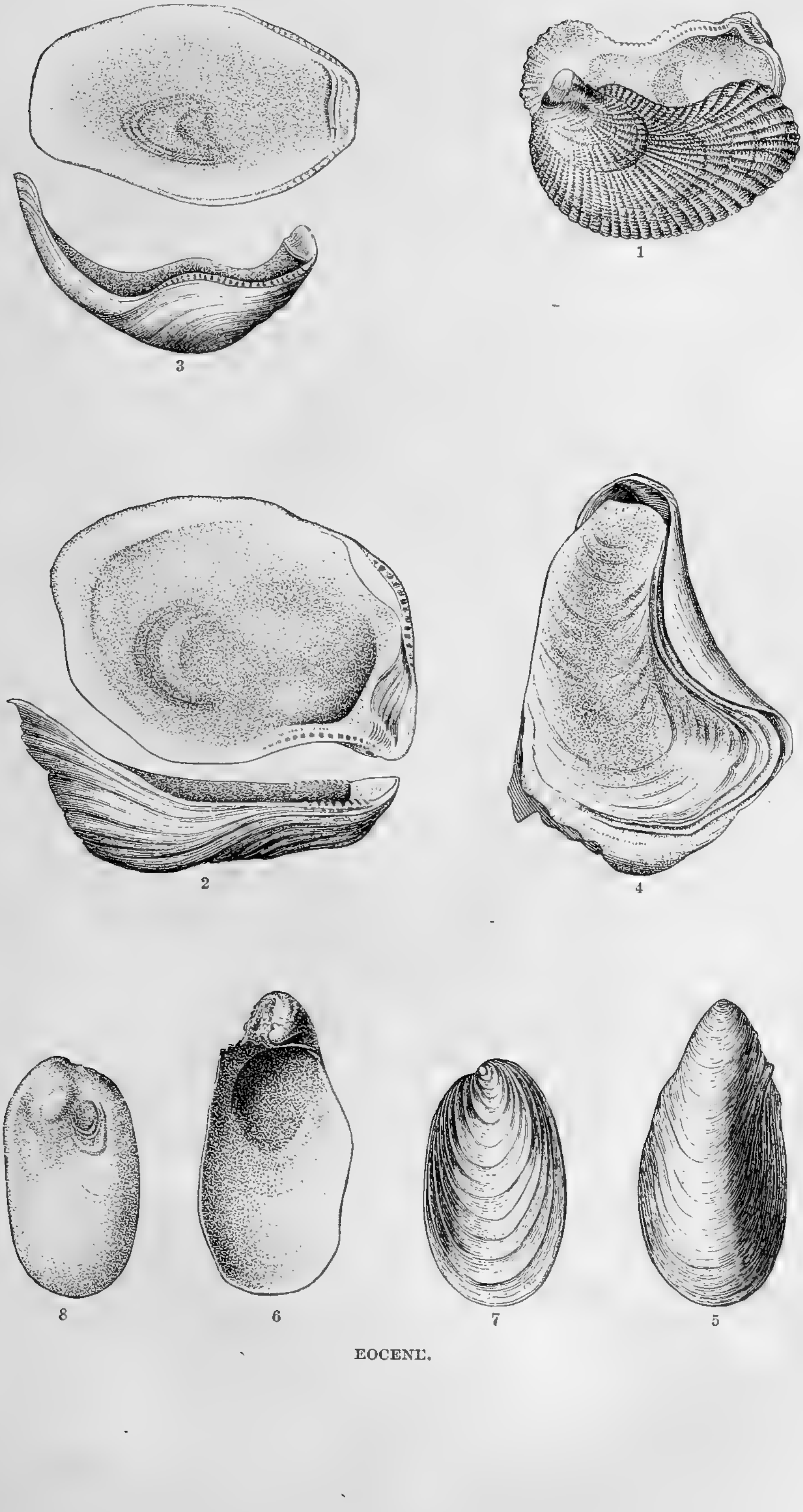
FIG. 1.—Copy of Lea's original figure.

OSTREA ALABAMENSIS Lea. (Page 309.)

FIG. 2.—Copy of Lea's original figure.
3.—Copy of Lea's figure of the form he called *O. lingua-canis.*
4.—Copy of Lea's figure of the form he called *O. semi-lunata.*

OSTREA EVERSA Mellville. (Page 310.)

5, 6.—Exterior and interior views of a lower valve.
7, 8.—Similar views of an upper valve. After Deshayes.



EOCENE.

PLATE LXV.

Ostrea compressirostra Say. (Page 309.)

Figs. 1, 2.—Upper and under views of a large example; natural size.

1

EOCENE.

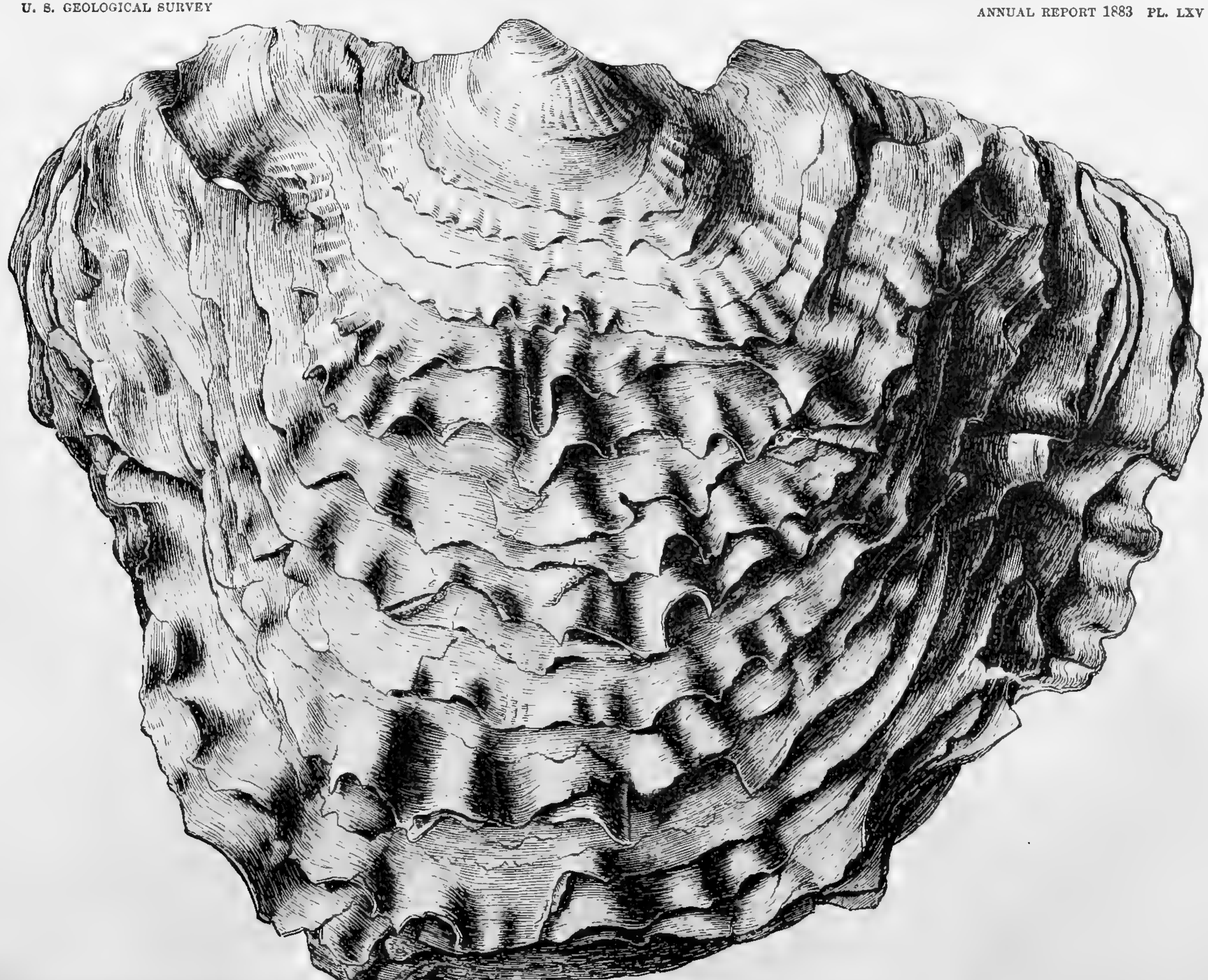
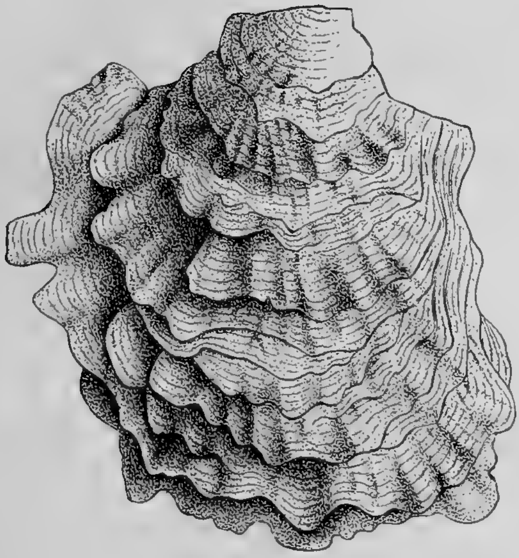


PLATE LXVI.

OSTREA DISPARILIS Conrad. (**Page 312.**)

FIG. 1.—Upper view; natural size.
2.—Under view of another example. **After Conrad.**



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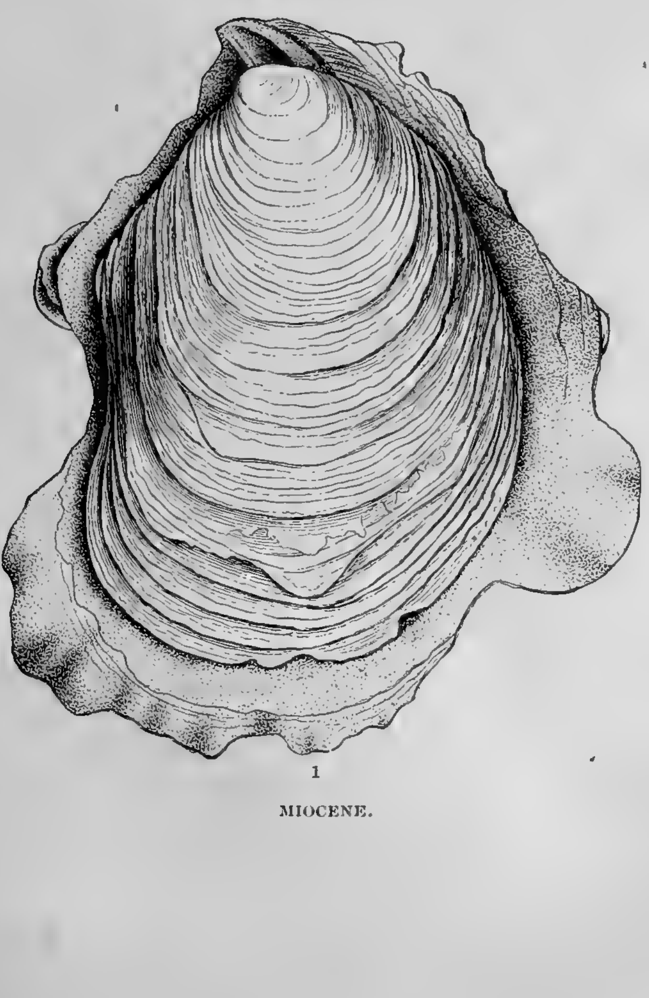


1

MIOCENE.

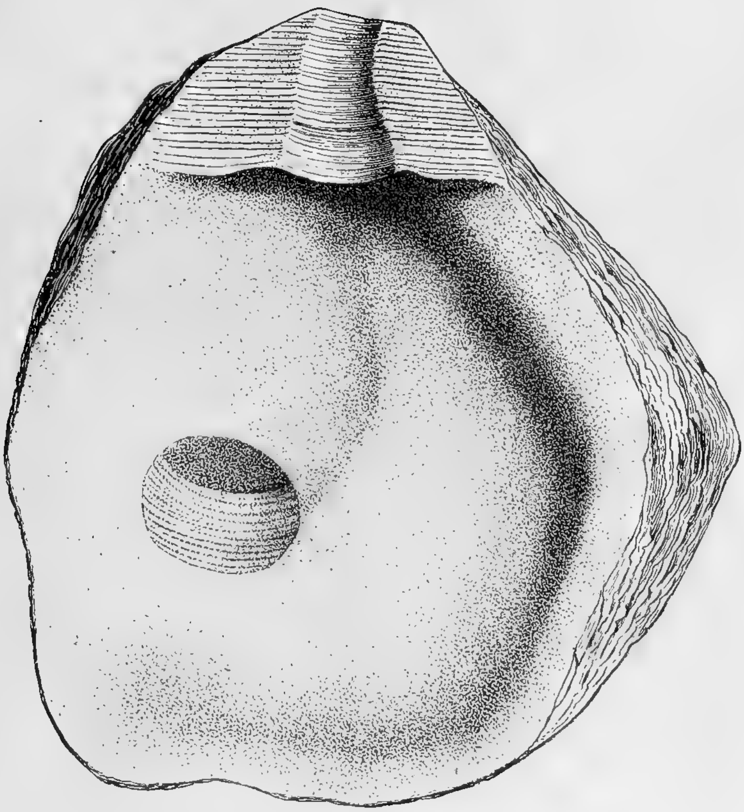
PLATE LXVII.

OSTREA TAYLORIANA Gabb. (Page 313.)

FIGS. 1, 2.—Upper and laterial views; natural size. After Gabb.

OSTREA PERCRASSA Conrad. (Page 313.)

3.—Interior view of a lower valve. After Conrad.



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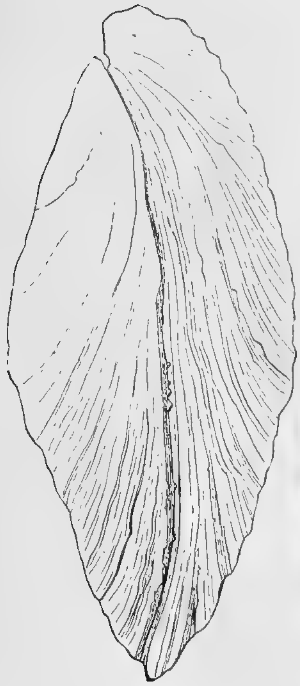

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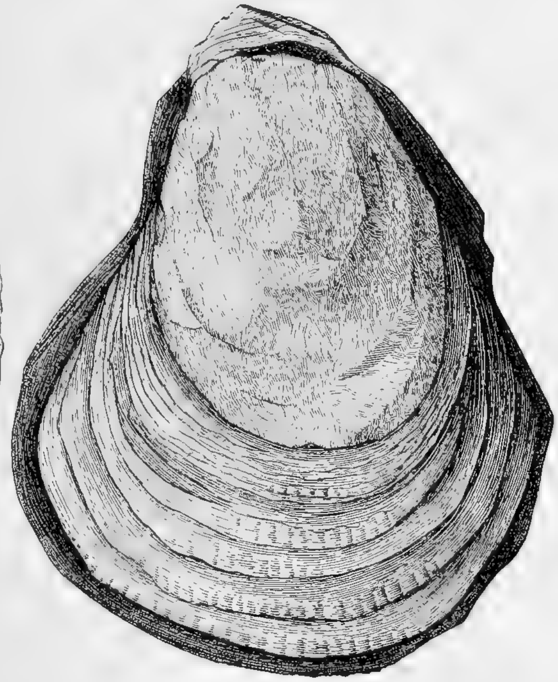


1

MIOCENE.

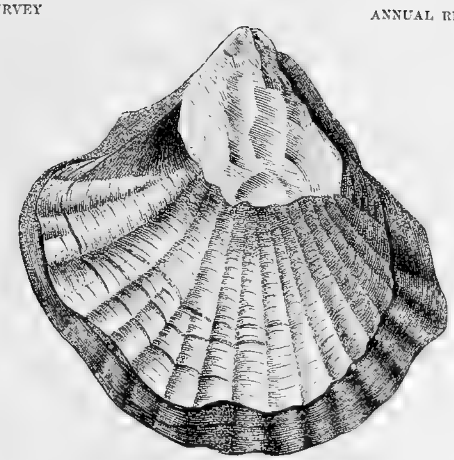
PLATE LXVIII.

OSTREA SUBFALCATA Conrad. (Page 313)

FIG. 1.—Upper view; natural size.
2, 3.—Exterior and interior views of an under valve.

OSTREA ATTWOODI Gabb. (Pages 312 and 314.)

4.—Exterior view of an under valve.
5.—Interior view of another under valve. After Gabb.



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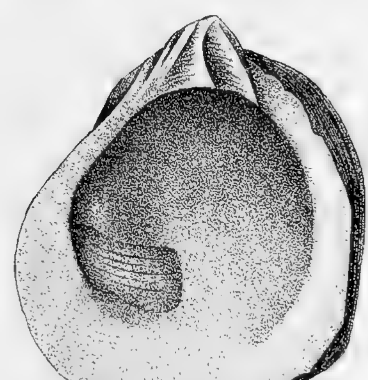

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2

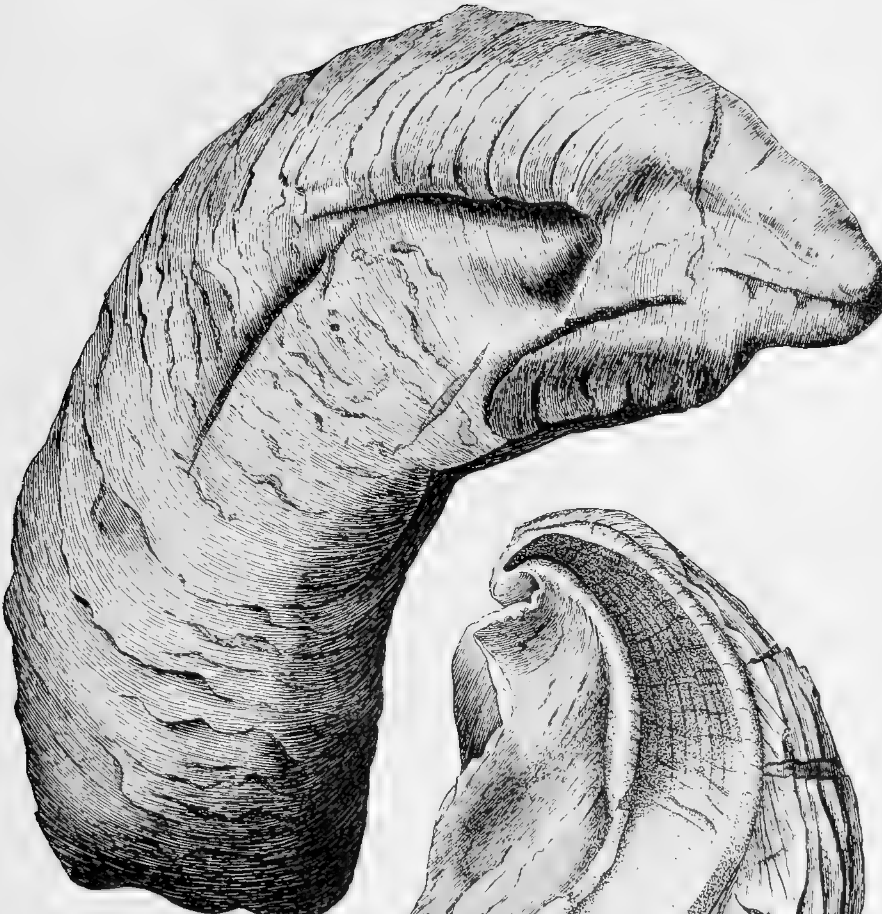
1

MIOCENE.

PLATE LXIX.

OSTREA CONTRACTA Conrad. (Page 312.)

FIGS. 1, 2.—Exterior and interior views of a large example; one-third actual diameter. After Conrad.



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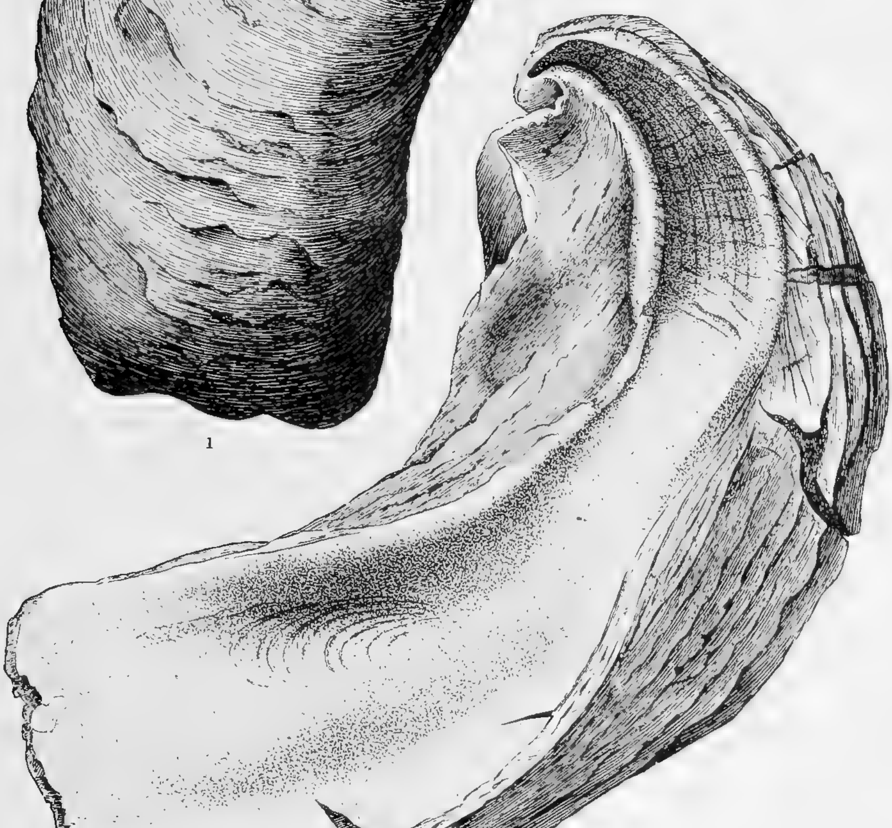


2

MIOCENE.

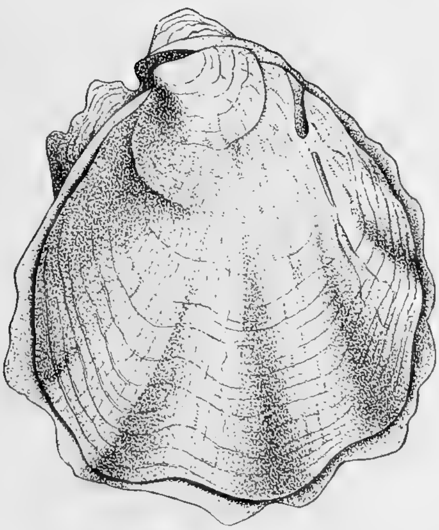
PLATE LXX.

OSTREA VELERIANA Conrad. (Page 314.)

FIG. 1.—Exterior view of a lower valve. After Conrad.

OSTREA SCULPTURATA Conrad. (Page 313.)

2.—Upper view. After Conrad.



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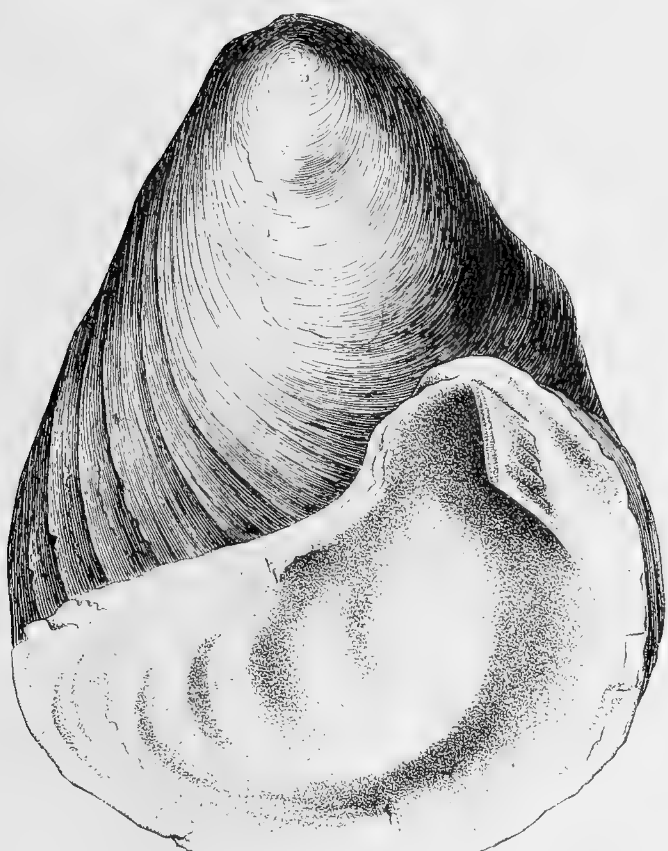


1

MIOCENE.

PLATE LXXI.

OSTREA BOURGEOISII (Remond) Gabb. (Page 314.)

FIG. 1.—Exterior view of a lower valve. After Gabb.

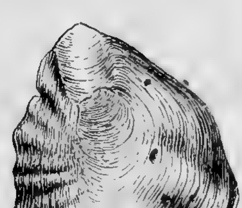
OSTREA VESPERTINA Conrad. (Page 315.)

FIGS. 2, 3.—Exterior and interior views of a lower valve.
4.—Exterior view of an upper valve. After Conrad.

2

3

5



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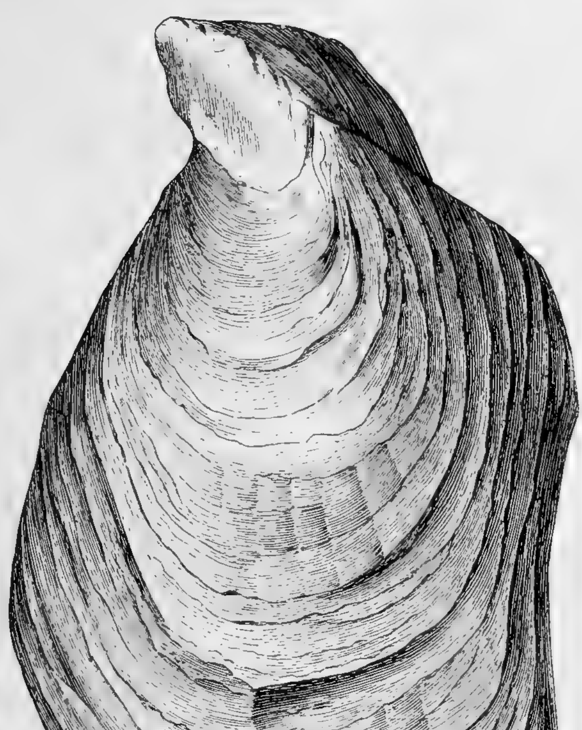


1

PLIOCENE.

PLATE LXXII.

OSTREA VEATCHII Gabb. (Page 316.)

FIG. 1.—Exterior view of a lower valve. After Gabb.

OSTREA CERROSENSIS (Raimondi) Gabb. (Page 315.)

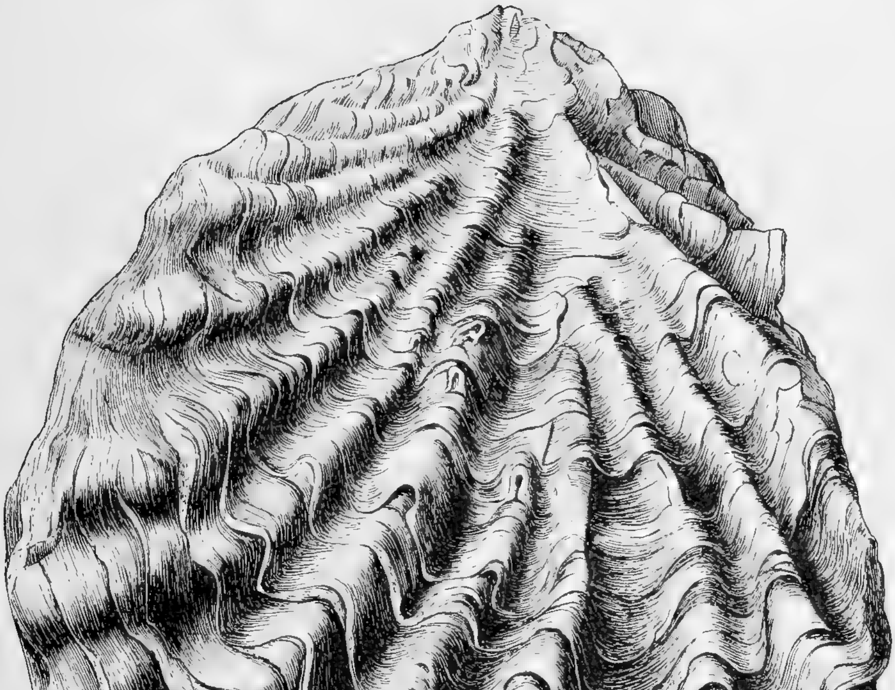
2.—Exterior view of an upper valve. After Gabb.

OSTREA LURIDA Carpenter. (Page 316.)

FIGS. 3, 4.—Exterior and interior views of a lower valve; natural size.

3

4



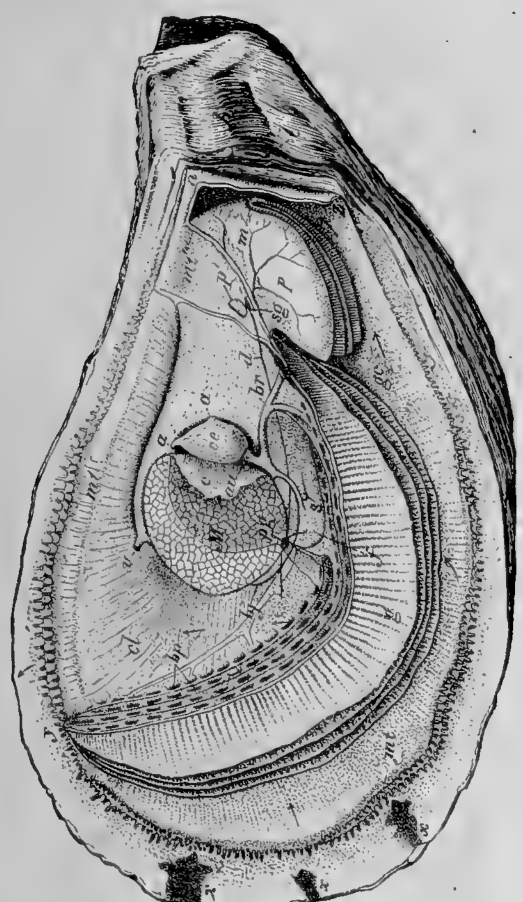
1

POST-PLIOCENE.

PLATE LXXIII.

FIG. 1 represents an American oyster in a moderately "fat" condition. The heart of this specimen, after being opened for over twenty-four hours and exposed to the air, would still beat feebly if irritated.

a and *a'*, great aortæ or arteries given off at these points from the ventricle; *au*, right auricle; *br*, branchio-cardiac vessels; *bj*, organ of Bojanus in outline; *bp*, branchial pores; *c*, pericardiac membrane of right side thrown back; *cl*, cloaca or cloacal space; *d*, nervous commissure of the right side connecting the parieto-splanchnic ganglion *pg* and the supraœsophageal ganglion *sg*; *f*, ventral process of the body-mass; *g*, gills; *gc*, gill cavity between the mantle leaves; *h*, grooved hinge-end of the left valve; *l*, ligament; *M*, adductor muscle; *mt*, mantle; *mt'*, portion of mantle adherent to body-mass; *n* to *z* marks the extent to which the right and left leaves of the mantle are confluent; *p*, palps or lips; *p'*, outer end of pedal muscle of right side; *s*, external opening of the generative and renal organs of the right side; *v*, vent or anus; *ve*, ventricle; *x*, *x*, *x*, cavities in the edge of the shell filled with mud; *y*, posterior extremity of the gills and junction of the leaves of the mantle.

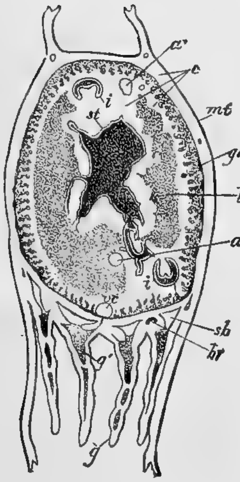


LIVING OSTREIDÆ.

PLATE LXXIV.

- FIG. 2 (lower). *Au*, auricle; *bm*, body-mass; *cl*, cloaca; *g*, gills; *i* and *i'*, intestine; *l*, liver, with its ducts opening into the stomach; *M*, adductor; *m*, month; *mt*, mantle; *o*, plane through which the section represented in Fig. 3 was cut; *p*, outer corrugated surface of inner or lower palp; *v*, vent; *ve*, ventricle.

FIG. 3 (upper). Section through the plane *o* of figure 2, viewed from the anterior side, and enlarged about two diameters; *a'* and *a''*, dorsal and ventral branches of the anterior aorta in section; *br*, branchial vessel; *c*, connective tissue; *g*, gills in section; *g'*, internal cavities of the gills; *ge*, layer of generative tissue or reproductive organ; *i*, *i*, cross-sections of the intestinal tube, showing the peculiar form of the internal cavity; *l*, liver or hepatic tissue; *mt*, mantle; *sb*, suprabranchial or water spaces above the gills; *st*, cavity of stomach; *vc*, vena cava.



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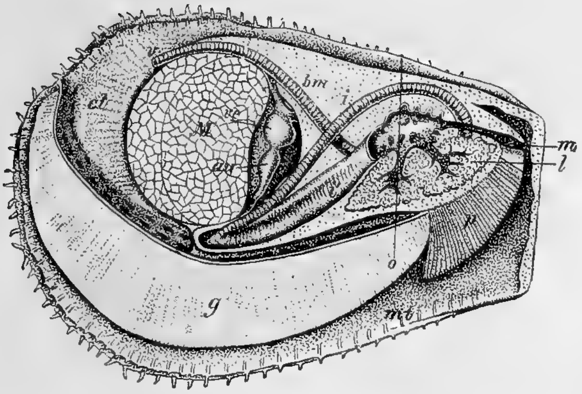


2

LIVING OSTREIDÆ.

PLATE LXXV.

FIG. 1.—Young American oyster, viewed from the side immediately after fixation by the mantle border *m*; enlarged 183 times.

2.—Four young European oysters taken from the beard of the parent; enlarged 96 times.

3.—Young American oyster, with the beaks or umbos of the larval shell developed, and firmly attached to an old oyster-shell; enlarged 96 times.

4.—Young American oyster, attached and beginning to form the spat shell. (The valves are slightly displaced.) Enlarged 96 times.

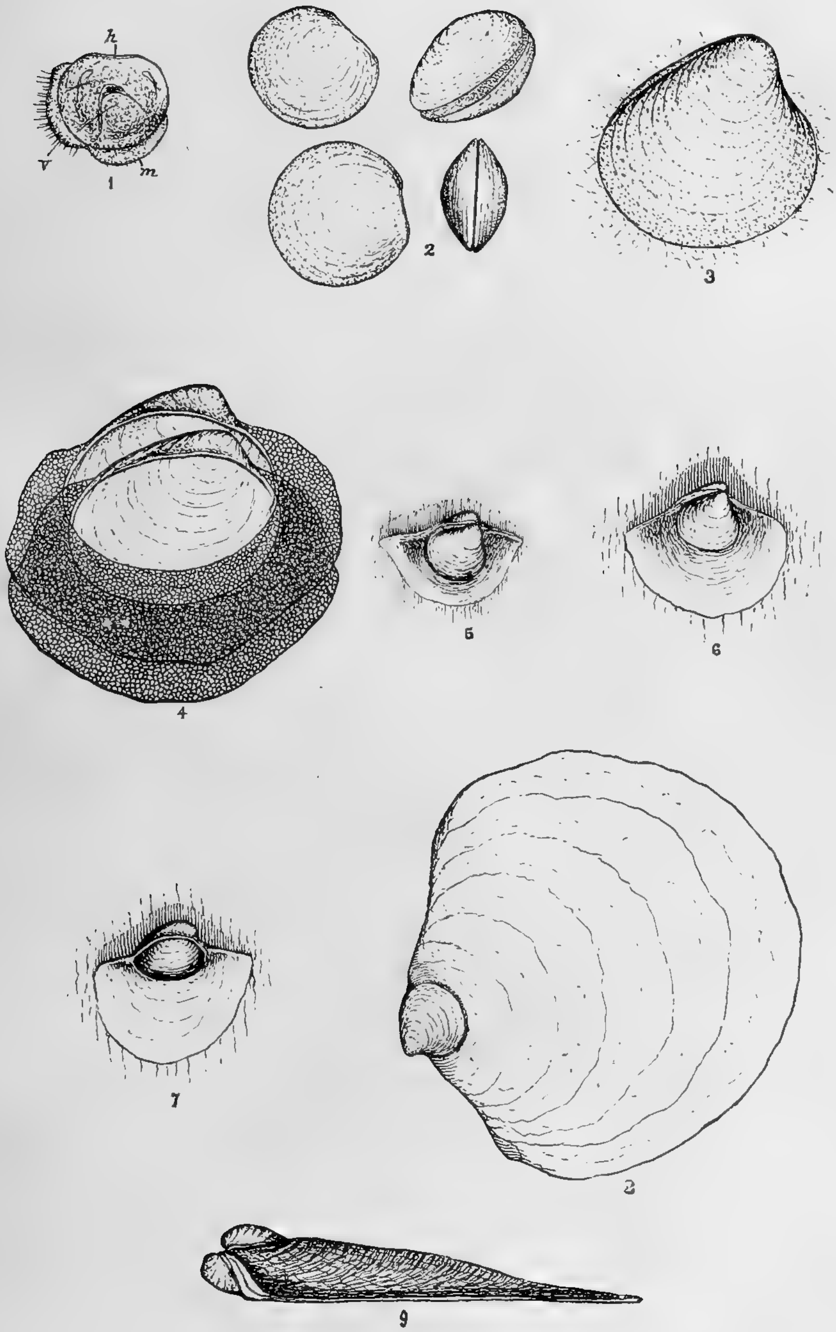
5, 6.—Very young spat of the American oyster, showing the peculiar form of the true larval shell and that of the spat, and the upwardly directed hinge border; enlarged 35 times.

7.—Lower valve of very young oyster, showing the great concavity of the larval valve and the abrupt transition into that of the spat stage; enlarged 35 times.

8.—Older spat viewed from the lower surface after being detached; enlarged 35 times.

9.—The same specimen viewed edgewise, to show the flat lower valve of the spat and the convex upper one, and the upturned hinge with the larval valves in place; enlarged 35 times.

N. B.—Figures 3, 4, 5, 6, 7 and 8 are unfortunately reversed, owing to an oversight in transferring the original camera lucida sketches. The peaks of the umbos should look to the left instead of to the right in order to bring them into a natural position. Otherwise these figures are accurate.



LIVING OSTREIDÆ.

3 INT——27

PLATE LXXVI.

FIG. 4.—Diagram of the soft parts of the American oyster, showing the extent of the generative organ *Gen*, and the courses of the efferent ducts of the left side, the main duct opening at the point *ov* below the adductor muscle *mus;* H, heart; MT, mantle; P, palps; G, gills.

5.—Twenty days' old spat of the American oyster viewed from above, natural size.

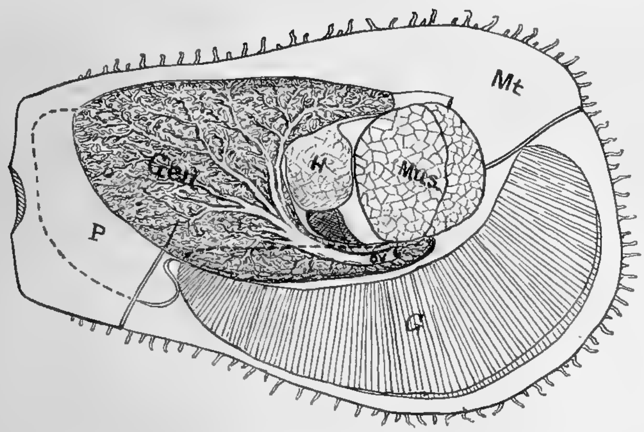
6.—Forty-four days' old spat, natural size.

7.—Forty-eight days' old spat, natural size.

8.—Young spat oyster, seventy-nine days old.

9.—Young spat oyster, eighty-two days old.

10.—Young oyster, 2½ to 3 months old, from inside of a wreck at Cape May, New Jersey.



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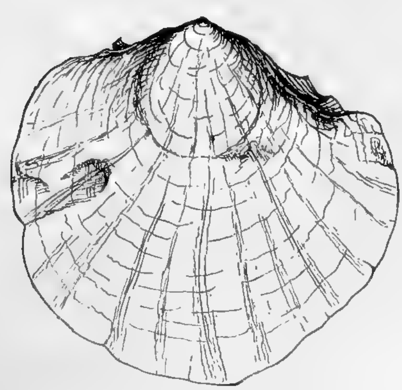

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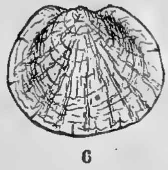

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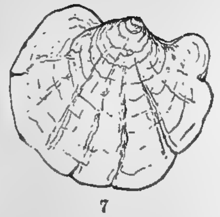

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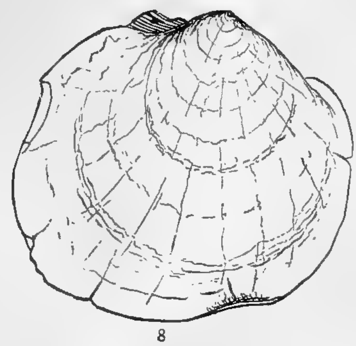

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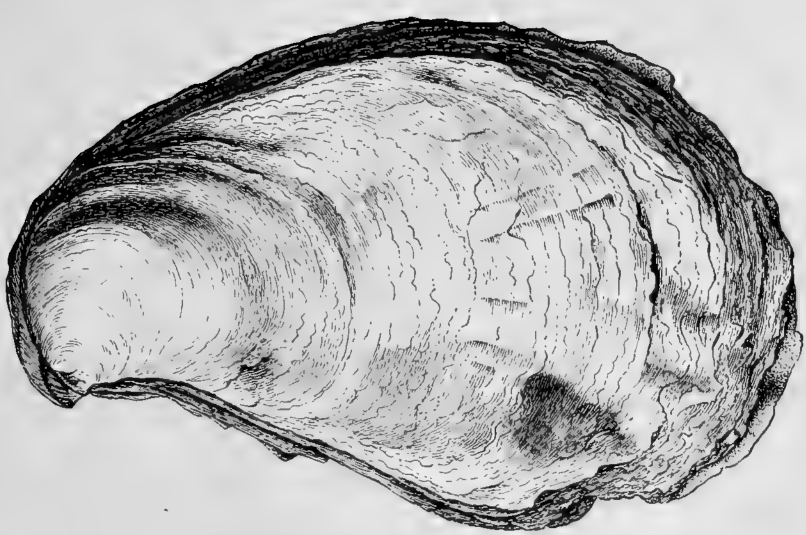
LIVING OSTREIDÆ.

PLATE LXXVII.

FIG. 1.—View of the inner face of the right valve of a typical American oyster.
FIG. 2.—View of the external surface of the preceding.

1



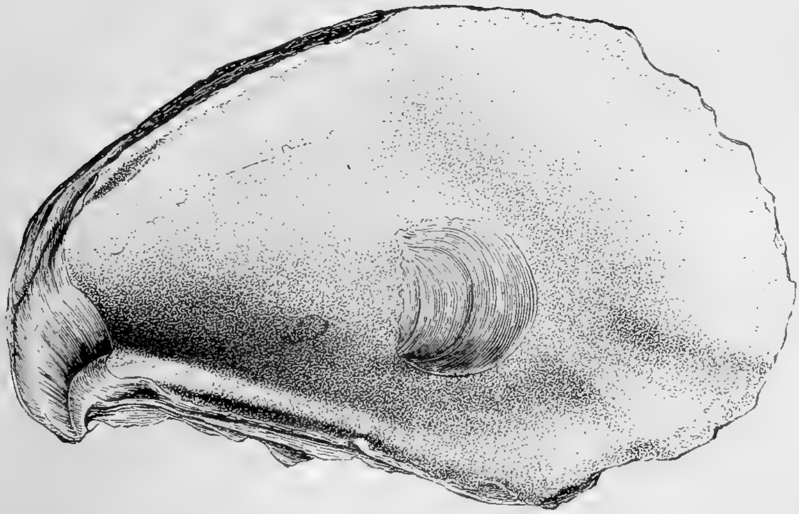
2

LIVING OSTREIDÆ.

PLATE LXXVIII.

FIG. 1.—View of the inner surface of the left or deepest valve belonging to the specimen represented on Plate lxxvii.

FIG. 2.—View of the external surface of the preceding.



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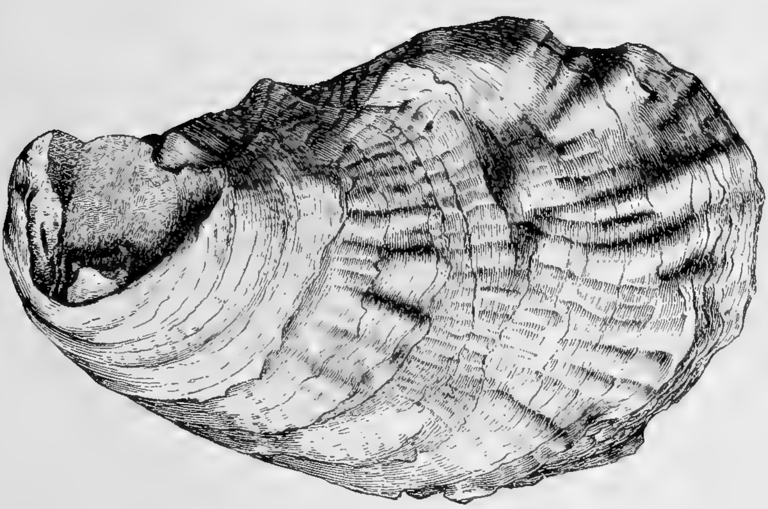

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LIVING OSTREIDÆ.

FIGURE LXXIX.

FIGS. 1, 2.—Views of the inside and side of the very ventricose or cup-like lower valve of a short and thick specimen of *Ostrea virginica*.

FIGS. 3, 4.—Views of the internal and external surfaces of the flat upper or right valve of the same specimen.

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LIVING OSTREIDÆ.

PLATE LXXX.

Views of the inner and outer surfaces of the right and left valves of the northern form of the American oyster, *Ostrea borealis*, showing the lower valve strongly fluted.

LIVING OSTREIDÆ.

PLATE LXXXI.

FIG. 1.—View of inner surface of the right valve of an elongated specimen of *Ostrea virginica*, known as the raccoon, "coon," or "cat's tongue" oyster among oystermen, natural size.

FIG. 2.—Both valves of the foregoing specimen place, with the outer surface of the right valve facing the observer.

LIVING OSTREIDÆ.

PLATE LXXXII.

Three views of the right and left valves of a smaller specimen of the raccoon or cat's tongue oyster.

LIVING OSTREIDÆ.